# MECHANICAL MINING IN SOME BITUMINOUS COAL MINES

## Progress Report 9: Face Haulage

By J. J. Shields and J. J. Dowd

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# MECHANICAL MINING IN SOME BITUMINOUS COAL MINES.[1]

## PROGRESS REPORT 9: FACE HAULAGE.

by

J. J. Shields[2] and J. J. Dowd[3]

## SUMMARY

This study by the Federal Bureau of Mines concerns different methods of face haulage used with various types of continuous-mining machines, mobile-loading machines, and track-mounted equipment under varying roof and bottom conditions and in coalbeds of varying thicknesses. This report is the ninth in a series on mechanical mining in bituminous coal mines. Reference to the reports previously published is made in appendix III, p. 106.

Use of modern mining equipment in bituminous coal mines has resulted in increased productivity at the face. This especially is true where continuous-mining machines are used, and the supervision is good. Previous methods and equipment for moving coal from the face became inadequate and had to be improved to restore balance to the mining systems. Sometimes new equipment was needed to improve the face haulage, and in some instances, a new combination of existing equipment was used.

Detailed studies of face haulage methods were made at 13 mines in Pennsylvania, West Virginia, Ohio, and Illinois to compare their effectiveness and to describe fully the conditions under which each method was used.

## INTRODUCTION

In early mining, coal was transported by manpower from the working place to the surface in small cars mounted on wood or iron rails. While the miner was tramming, the loading operation was stopped. Usually entries were driven on a slight ascending grade to favor the load and for natural drainage. As hauls became longer, animals were used instead of manpower, and later, machinery replaced animals; until today only small mines rely on them for haulage. Partings or gathering tracks were established near the working faces where empty cars could be stored and the loads assembled into trips. Cars then could be transported in trips rather than singly, thus permitting more rapid return of the empties to the working areas without delays to the loading phase of the mining cycle.

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As coordination of the loading and haulage cycles became important to production, a trip of loads was on the parting track for the mainline haulage unit to bring a trip of empties. Miners waiting for empty cars to load or tne haulage unit ready for loads to haul decreased the production time of a mine.

With each improvement in mechanization resulting in increased production at the face, mine management has devised new methods of haulage to avoid bottlenecks. Now with continuous-mining machines and improved conventional mining machines with rated peak capacities to 15 tons a minute, more rapid removal of the mined coal from the face is necessary if improved mining machinery is to be utilized to the fullest extent. Transporting mined coal from the face to the surface in many instances has become a complex network of face, intermediate, mainline, and portal haulage accomplished by combinations of many types of machines and equipment. Although complicated, the various phases of haulage must be coordinated to operate smoothly and without delay to maintain a steady flow of coal from the face to the surface tipple.

## ACKNOWLEDGMENTS

The Federal Bureau of Mines thanks the officials of coal mining companies for their cooperation in permitting this study to be made in their mines and for the courtesies extended to the Bureau engineer assigned to the work. The suggestions and comments of mine officials who reviewed the individual mine reports and who granted the Bureau permission to publish the information obtained are appreciated.

## PROCEDURE

Once permission was received from coal-company officials whose mine was selected for study, the Bureau engineer spent several days underground at the working faces observing the production and face haulage equipment and also the methods employed in transporting the coal in intermediate and mainline haulage. Sketches were made showing the mining plans, face and intermediate haulage systems, thickness of coal bed, partings, and thickness mined. A section of the overburden in the mining area was obtained from company drill logs, and a sketch was made showing the thickness of the strata and surface material.

A distribution of the 8-hour shift was made for each mine to determine the maximum production time available. Delays especially attributable to face haulage equipment were recorded. This information was checked with company records covering the previous 3- to 6-month period. Classification of all mine employees as well as the mine production per shift was obtained from company records for the same period, not only for the units studied at that mine but for other units in use.

After each mine study was completed, a report was prepared and submitted to the operator for his comments and permission to publish the information.

## HAULAGE - GENERAL

Haulage refers to the process of moving the coal mined at the face to the mine tipple. It does not include the transportation of men and supplies that use the same equipment. For convenience, the transportation system can be divided into four parts: Portal haulage (shaft, slope, and drift); mainline haulage; intermediate haulage; and face haulage. These subdivisions are not necessarily made in all transportation systems as the intermediate haulage may be the mainline and the portal haulage may be a continuation of the mainline. This study deals chiefly with face haulage, but a short description of the other haulage also is given.

The portal haulage used depends on the type of mine opening. In vertical shafts, hoisting of loaded mine cars on cages to the surface is being eliminated in favor of skips that are loaded automatically from a bottom dump. Slopes sunk on dips not exceeding 17 degrees are equipped with belts in most of the newly developed mines and some of the older mines. Where slope belts are used, a supplementary track system transports men and supplies. In drift mines this haulage is a continuation of the mainline haulage whether it is done by locomotives, belts, or even shuttle cars.

Mainline haulage is the movement of mined coal from gathering stations in the mine to the portal and usually is accomplished by locomotives pulling mine cars or by belts fed by other conveyors. Locomotives up to 50 tons operated singly or in tandem pull trips of as many as 25 cars ranging to 20-ton capacity. Track rails weighing up to 120 pounds per yard are either bolted or welded and are laid on wood ties in a ballasted road bed. Locomotive operators are in constant touch with dispatchers and other locomotive operators by two-way radio. Block signals and automatic switch throws are operated from the cab of the locomotive without stopping. Speeds of 15 miles or more per hour are maintained by the mainline trips. Belts used in mainline transportation show a trend from the rigid frame construction to the rope type.

Intermediate haulage is the transportation of mined coal from the face haulage to that point where it is accessible to the mainline. It is accomplished by conveyors, belts, or locomotives and mine cars. Where gathering belts or conveyors are used, the end of this phase of haulage is at the transfer point of the coal to mine cars or to a mainline belt. With locomotives and mine cars, it would end at the partings where the loads are assembled into trips for the mainline locomotive.

## FACE HAULAGE

Face haulage in this report means the transportation of mined coal from the working face to an intermediate haulage. It is accomplished by shuttle cars, conveyors, locomotives, and mine cars, or combinations of such equipment. The study was planned to determine the types of equipment used; the manpower requirements; the tons produced per man shift; and to compare the several systems. Special attention was given to delays chargeable to the face haulage that caused stoppage or limitation of coal loading. If two face haulage systems were used at a mine studied, both were investigated for comparison.

## Shuttle Cars

Table 1 summarizes the face-haulage systems at the 13 mines studied. Shuttle cars were used at eight of the mines and received the coal directly from the continuous-mining machine or loading machine; from a surge car behind the face equipment; or from a loading machine operated behind a continuous-mining machine. All shuttle cars were the cable type, and where more than one was required for the face equipment, separate travelways were provided.

TABLE 1. - Face equipment and transportation to intermediate haulage

| Mine No. and unit | Face mining equipment | Sequence of transfer from loading equipment to intermediate haulage | Intermediate haulage |
|---|---|---|---|
| 1(a) | Auger C.M.1/ | Bridge conveyor - chain conveyor | 24-inch belt to cars |
| 2(a) | do. | do. | 30-inch belt to storage bank |
| 3(a) | M.L.2/ | do. | 30-inch belt to 3-ton cars |
| 3(b) | do. | Loading machine - chain conveyor | Do. |
| 4(a) | Ripper C.M.3/ | 24-inch extensible belt | 30-inch belt to 5-ton cars |
| 4(b) | do. | Surge car - shuttle car | Do. |
| 4(c) | do. | do. | Do. |
| 5(a) | Boring C.M.4/ | 30-inch extensible belt | Do. |
| 6(a) | Ripper C.M.3/ | Loading machine - shuttle car | 8-ton cars |
| 6(b) | do. | do. | 30-inch belt |
| 6(c) | M.L.2/ | Shuttle car | 8-ton cars |
| 6(d) | T.L.5/ | Locomotive and mine car | Do. |
| 7(a) | Ripper C.M.3/ | 24-inch extensible belt | 6-ton cars |
| 7(b) | M.L.2/ | Shuttle cars | Do. |
| 8(a) | Ripper C.M.3/ | Loading machine - shuttle car | 10-ton cars |
| 8(b) | M.L.2/ | Shuttle car | Do. |
| 9(a) | T.L.5/ | Locomotive and mine car | Do. |
| 9(b) | do. | do. | Do. |
| 9(c) | do. | do. | Do. |
| 10(a) | M.L.2/ | Shuttle cars | Do. |
| 10(b) | T.L.5/ | Locomotive and mine car | Do. |
| 11(a) | Boring C.M.6/ | 36-inch extensible belt | 42-inch belt |
| 11(b) | M.L.2/ | Shuttle cars | Do. |
| 12(a) | Ripper C.M.3/ | 30-inch extensible belt | 30-inch belt |
| 12(b) | do. | Shuttle cars | Do. |
| 12(c) | M.L.2/ | do. | Do. |
| 13(a) | do. | do. | Shuttle cars |

1/ Shortwall auger continuous-mining machine.
2/ Mobile-loading units.
3/ Ripping action continuous-mining machine.
4/ Boring action continuous-mining machine with a series of rotating arms.
5/ Track-loading units.
6/ Boring action continuous-mining machine with two rotating arms.

### Conveyors

Two types of conveyors were used in face haulage: Extensible belt, and chain. The extensible belts were used in coal more than 50 inches thick, and chain conveyors were employed in thin coal. The extensible belts received the mined coal from continuous-mining machines over a bridge between the units. Equipment outby the extensible belt was not considered face haulage.

Because of the low headroom required, chain conveyors are used extensively in thin coal. The face equipment can load directly to the conveyor or, as is being done more frequently, to a bridge conveyor to the chain conveyor. Equipment outby the chain conveyor discharge was not considered face haulage.

### Locomotives and Cars

Because of the trend to trackless type loading equipment, locomotive-car face haulage is on the decline. However, where mine cars of 6- to 10-ton capacity can be loaded at the face and where the car change can be held to a short haul, it is usable with some types of loading machines.

## MINE DESCRIPTIONS

Each mine is described so that details of the face-haulage systems can be compared, and data can be used in formulating a face-haulage system most suitable for selected mining conditions. A classification of employees at each mine is given in appendix I, and a summary of operation for the mine is presented in appendix II.

### Mine 1

This mine is operated in the flat-lying Lower Freeport coalbed which averages 36 inches thick in this area. The bed is overlain by 1 to 2 inches of draw slate which is taken down and gobbed during mining. The coal is underlain by a shale binder 2 inches thick below which is 2 to 4 inches of high-ash coal. The 30 to 32 inches of coal above the binder is mined. (See fig. 1.) The overburden consists mainly of shales and sandstones and averages 244 feet thick. Loaded mine cars are hauled by a 13-ton locomotive in 37 car trips over 36-inch gage track (60-pound rail) to a tipple on the surface.

The mine is operated two shifts a day and produces an average of 1,100 tons of raw coal with the following units:

(a) 2 shortwall auger-type continuous-mining units each with a bridge conveyor and a chain conveyor for mining rooms or to develop entries; 5 men in each crew; 4 unit shifts per day;

(b) 5 shaking conveyor units to mine rooms and develop entries; 7 men in each crew; 2 shifts per day.

A detailed study was made of the continuous-mining units working in rooms and entries.

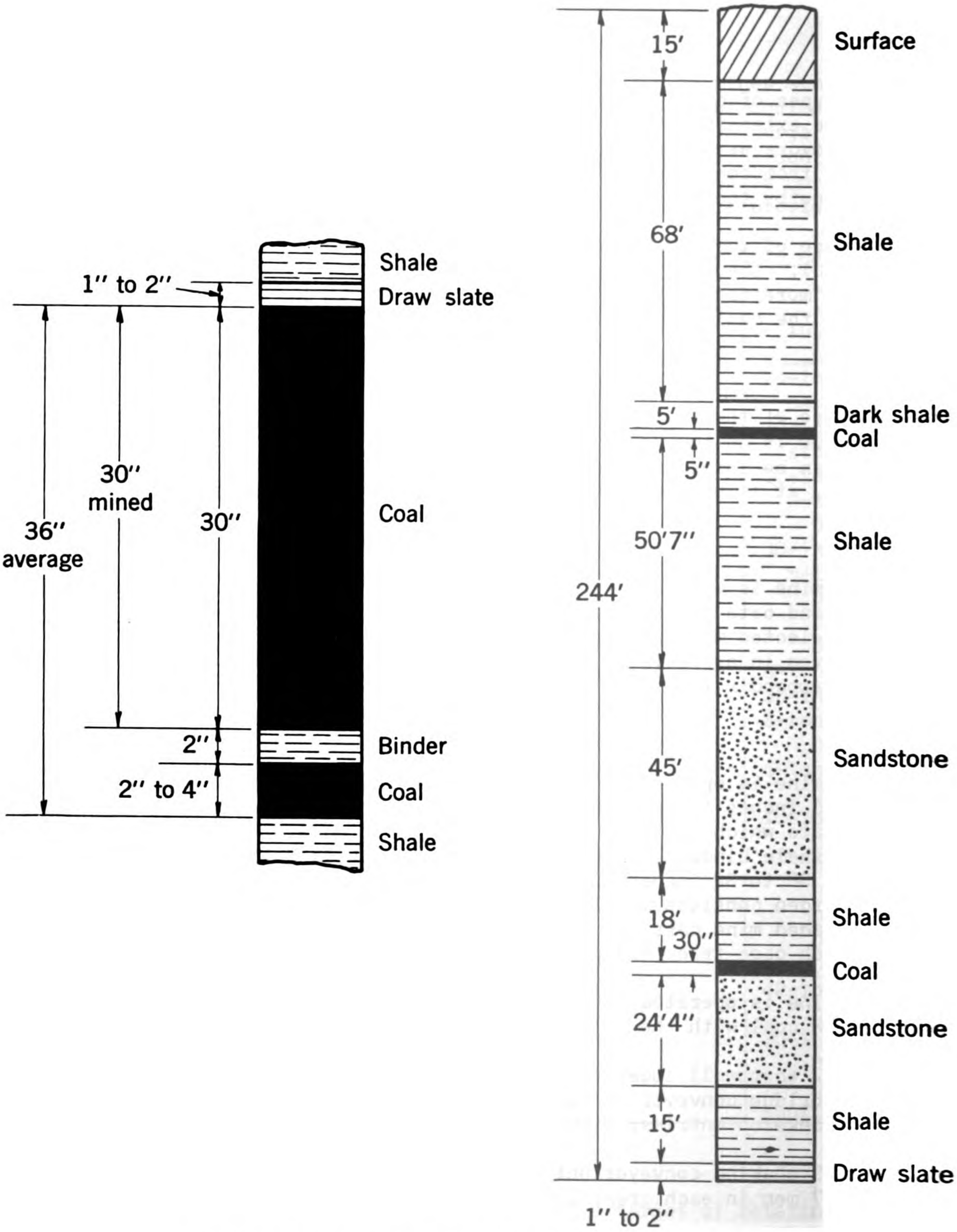

FIGURE 1. - Section of Coalbed and Overburden at Mine 1.

Main entries in sets of four are driven 30 feet wide on 70-foot centers with crosscuts 16 and 20 feet wide as projected. Butt entries in sets of two are turned on 550-foot centers and are driven 30 feet wide on 50-foot centers to a depth of 900 feet. Crosscuts are turned on 50-foot centers and are driven 20 feet wide. Rooms are driven 300 feet long and 40 feet wide on 50-foot centers with crosscuts 20 feet wide on 60-foot centers. (See fig. 2.) Rooms and entries are timbered with wood posts set on 4-foot centers and, where necessary, with 3- by 8-inch wood crossbars 16 feet long set on wood posts. Rock dusting is done by hand on shift.

The two entries are advanced simultaneously. The chain conveyor in each entry discharges the coal onto a cross chain conveyor (through a crosscut) which delivers the coal to a 24-inch belt in the outby entry. The outby entry is brushed along the outby side of the belt for a travelway 4 feet high and 8 feet wide. The brushing is done on the third shift by a rock crew. Usually

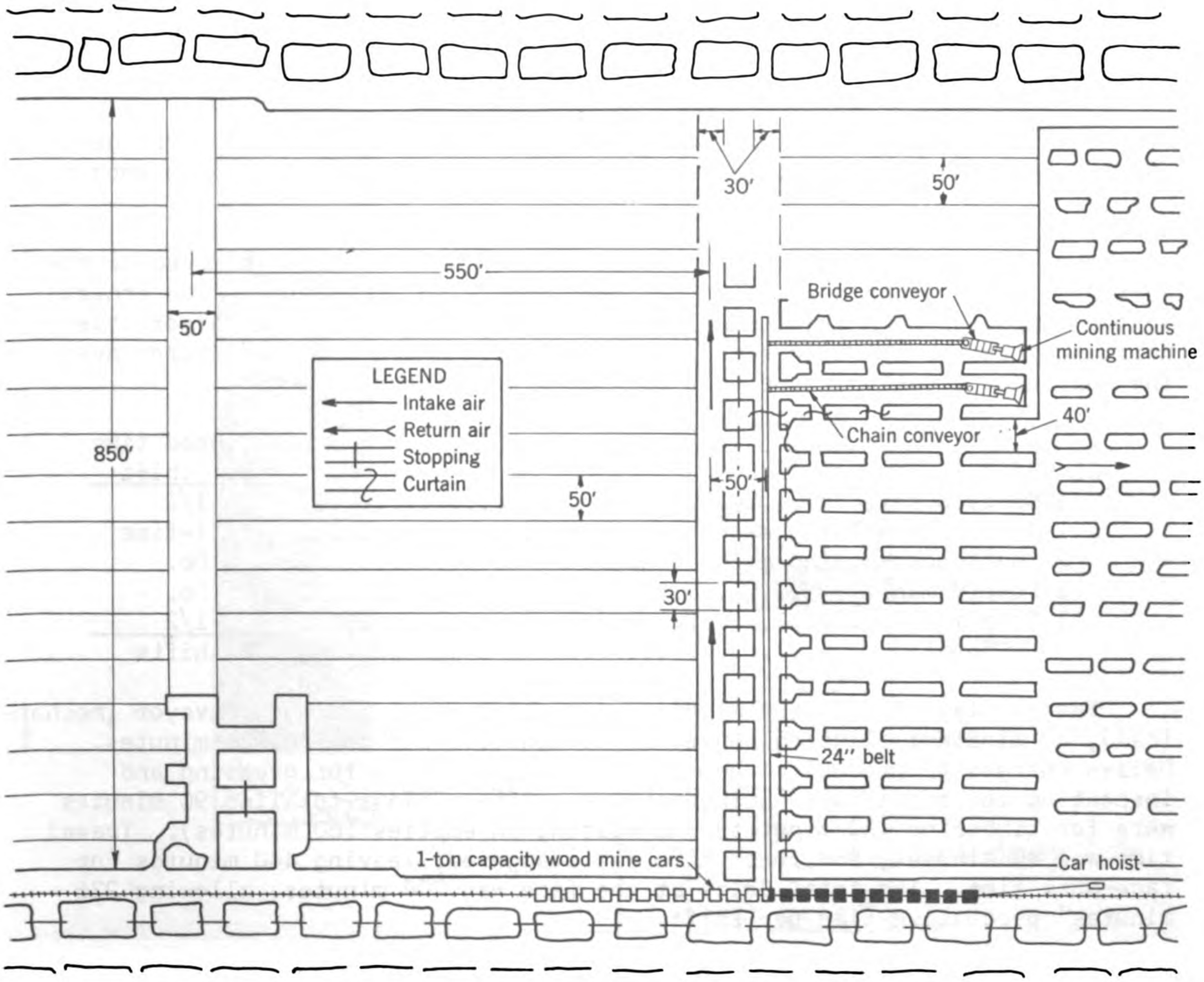

FIGURE 2. - Entry Development and Room-Mining Plan with Continuous-Mining Machine Using Bridge Conveyors to Chain Conveyors at Mine 1.

the entries are advanced 150 to 200 feet, and the outby rooms are necked before the continuous-mining units are retracted for room mining. Rooms are mined off the outby entry on advance and off the inby entry on retreat.

A continuous-mining unit consists of five men, one auger-type continuous mining machine with bridge conveyor, one chain conveyor 260 feet long, one portable hoist, and a three-wheel supply cart. One cross-chain conveyor, one wheel-mounted elevating conveyor, one 40-gallon pump, one 24-inch belt, and one car hoist serve two units. Power to operate the mining machinery is furnished at 250 volts direct current.

An operator and two helpers perform all tasks required to mine coal in each working place. This includes operating the machine, timbering, and advancing the chain conveyor, usually two 6-foot sections at a time. The average advance of each room or room and crosscut is 30 feet per shift or 60 feet for the two units. A unit produces 100 tons of raw coal per shift or 20 tons per shift for each man in the section unit crew. A supply man delivers supplies, posts, and chain conveyor sections to the working face with a three-wheel cart.

Coal is transferred from the continuous-mining machine to the bridge conveyors, to chain conveyors, to a 24-inch belt, and to 1-ton end dump wood mine cars.

When a room is completed, the continuous-mining machine is moved to the next room where a chain conveyor has been installed previously. The conveyor in the completed room is dismantled by the two supply men using a portable hoist to drag the conveyor sections to the entry where they are stored near the next room location. The unit crew consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.................................... | 1/2 |
| 1 Continuous-mining machine operator................ | Full-time |
| 2 Continuous-mining machine operator helpers........ | Do. |
| 1 Supply man........................................ | Do. |
| 1 Boom man.......................................... | 1/2 |
| Total........................... 6 men working | 5 shifts |

Face-haulage delays (84 minutes) per shift were: Bridge conveyor (mechanical), 20 minutes; aligning conveyor, 40 minutes; and moving, 24 minutes. Delays charged to production equipment were 30 minutes for greasing and inspecting the continuous-mining machine. Other delays totaling 90 minutes were for timbering (30 minutes) and waiting on empties (60 minutes). Travel time was 40 minutes, and lunch time was staggered, leaving 440 minutes for face-work time. The total delay at the face was 204 minutes, allowing 236 minutes' productive time per shift.

## Mine 2

This mine is operated in the Peerless coalbed which averages 42 inches thick and is relatively free of partings or other impurities in this area. (See fig. 3.) The dip of the bed is 5 to 6 percent in a southeasterly direction. The coal is underlain by fire clay and is overlain by 12 inches of dark clayey shale. The overburden consists mainly of shales and sandstone and averages 250 feet thick.

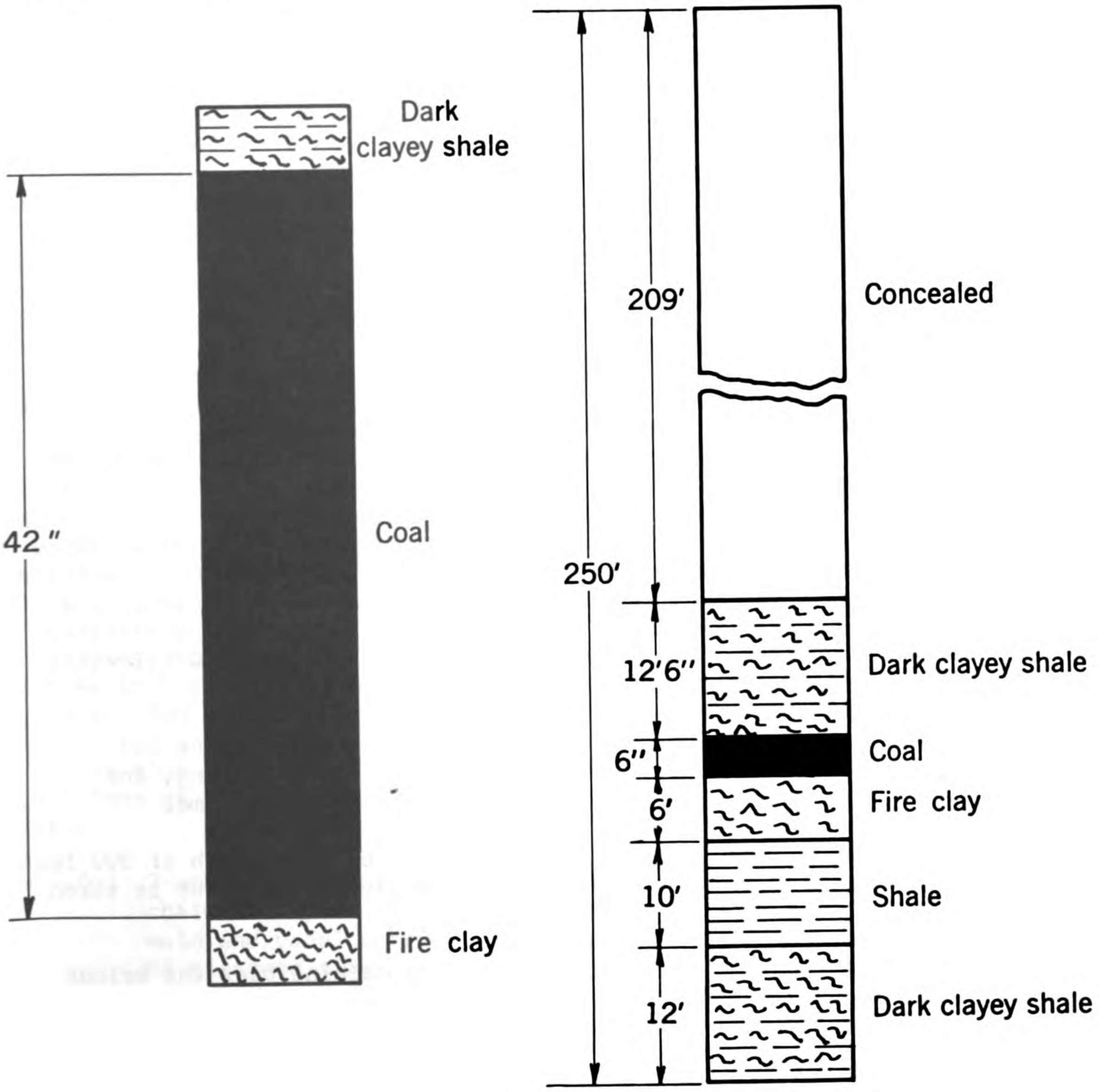

FIGURE 3. - Section of Coalbed and Overburden at Mine 2.

The mine is operated two shifts a day and produces daily an average of 540 tons of raw coal with the following units:

(a) 2 shortwall auger-type continuous-mining units, each with a bridge conveyor and a chain conveyor for mining rooms or to develop entries; 4-1/2 men to each crew (on the basis of assigned time per shift); 4 unit shifts per day.

Main entries in sets of three are driven 18 feet wide on 70-foot centers with crosscuts 16 feet wide on 60- and 90-foot centers. Panel entries in sets of three are turned on 600-foot centers and are driven 18 feet wide on 50-foot centers to varying depths to the lease line. Crosscuts were turned on about 90-foot centers but will be turned 20 feet wide on 50-foot centers in future extensions. Rooms are driven 50 feet wide on 60-foot centers to a depth of 300 feet. Crosscuts 10 feet wide are turned on 40-foot centers. (See fig. 4.) Rooms and entries are timbered with wood posts set on 4-foot centers and, where necessary, with 4- by 12-inch wood crossbars 16 feet long set on wood posts. Rock dusting is done by hand on shift.

The three entries are advanced together with two continuous-mining machines that discharge coal to chain conveyors. The middle entry is equipped with a 30-inch belt which is end-loaded by the chain conveyor in the center entry and by cross-chain conveyors in crosscuts from the outside entries. The belt is extended every 200 feet as the entries are advanced. The chain conveyors are dismantled and moved at the same time. Rooms are mined on retreat from the outside entries.

A continuous-mining unit consists of 4-1/2 men (on the basis of assigned time per shift); one continuous-mining machine with bridge conveyor; one chain conveyor 300 feet long; one 30-inch belt; and one 3-wheel supply cart. One cross chain conveyor serves two units. Power to operate the mining machinery is furnished at 250 volts direct current by two diesel-powered 100 kilowatts generator sets wired in parallel and located on surface.

An operator and two helpers perform all tasks required to mine coal in each working place. This includes operating the machine, timbering, and advancing the chain conveyor, usually two 6-foot sections at a time.

Rooms are driven 27 feet wide as they are advanced to a depth of 300 feet. The machine then is turned to the outby rib, and a 23-foot wide cut is taken on retreat, making the completed room 50 feet wide.

Coal is transferred from the continuous-mining machine over the bridge conveyor to a 15-inch chain conveyor, then to the 30-inch belt in the middle-panel entry, and then to a 30-inch belt in the middle main entry. Coal is conveyed to the surface and dumped on an elevating (stacker) conveyor that discharges into a storage bank where it is distributed evenly by a bulldozer. The coal is loaded with a 1-cubic-yard shovel into trucks of 10- and 13-ton capacity and is transported 1 mile to a tipple.

The average advance of each room 27 feet wide, or room and crosscut, is 38 feet per shift or 76 feet for the two units. A unit produces 135 tons of raw coal per shift. This is 30 tons for each man in a unit crew. A supply man with a 3-wheel cart delivers supplies, posts, and chain conveyor sections to the working face. The unit crew consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | 1/2 |
| 1 Continuous-mining machine operator | Full-time |
| 2 Continuous-mining machine operator helpers | Do. |
| 1 Supply man | Do. |
| Total 5 men working | 4-1/2 shifts |

Face-haulage delays per shift (75 minutes) were bridge conveyor (mechanical), 15 minutes, and aligning conveyor, 60 minutes. Production delays were 45 minutes for greasing and inspecting the continuous-mining machine. Other delays were 15 minutes for timbering, 15 minutes for travel, and 30 minutes for lunch, leaving 435 minutes for face work. The total delay at the face was 135 minutes, allowing 300 minutes' productive time per shift.

## Mine 3

This mine is operated in the Cedar Grove bed which ranges from 36 to 56 inches thick in the area and has two shale partings 2 and 4 inches thick which occur 2 and 8 inches above the bottom. (See fig. 5.) The bed is overlain by sandstone. The overburden consists of shales, sandstones, and several coalbeds and ranges up to 772 feet in thickness. The coalbed is underlain by shale that heaves in parts of the mine. Horsebacks or rolls in the roof and bottom and thin coal areas are encountered in mining.

Loaded mine cars are transported in 16 car trips by 10-ton locomotives over 42-inch gage (40- and 60-pound rail) track to a cleaning plant on the surface. Men and supplies are transported in mine cars to the working faces.

The mine is operated three shifts per day and produces an average of 1,406 tons of raw coal that yields 1,230 tons of clean coal with the following units:

(a) 2 mobile-loading units, each with 2 bridge conveyors and 2 chain conveyors that discharge on to a 30-inch belt to develop main and panel entries; 8-1/2 men in each crew (on the basis of assigned time per shift); 4 unit shifts per day;

(b) 1 mobile-loading unit with 2 lines of chain conveyors discharging onto a 30-inch belt to mine rooms in barrier pillars; 9 men in each crew; 3 unit shifts per day;

(c) 2 mobile-loading units, each with chain conveyors discharging onto a 30-inch belt to develop entries and mine rooms; 8-1/2 men in each crew (on the basis of assigned time per shift); 2 unit shifts per day.

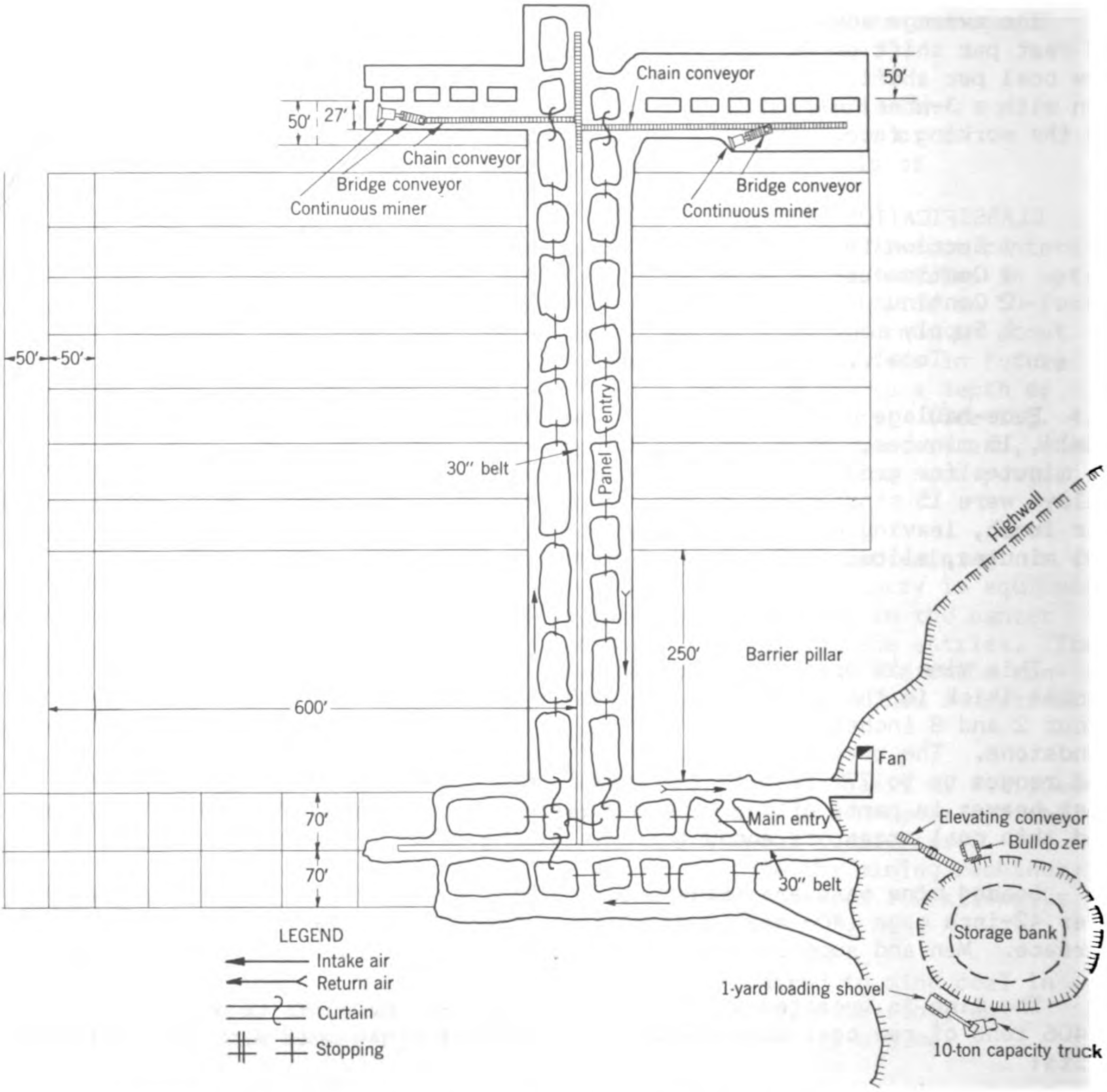

FIGURE 4. - Entry Development and Room-Mining Plan with Continuous-Mining Machines Using Bridge Conveyors to Chain Conveyors at Mine 2.

A detailed study was made of one unit of the (a) group in 36-inch coal and the (b) unit in 56-inch coal to compare the two systems of face haulage.

## A Unit

The mine is developed by a system of multiple entries. Main and cross mains are driven 16 to 26 feet wide in sets of four on 50-foot centers with crosscuts 12 to 16 feet wide on 50- and 100-foot centers. The bottom is

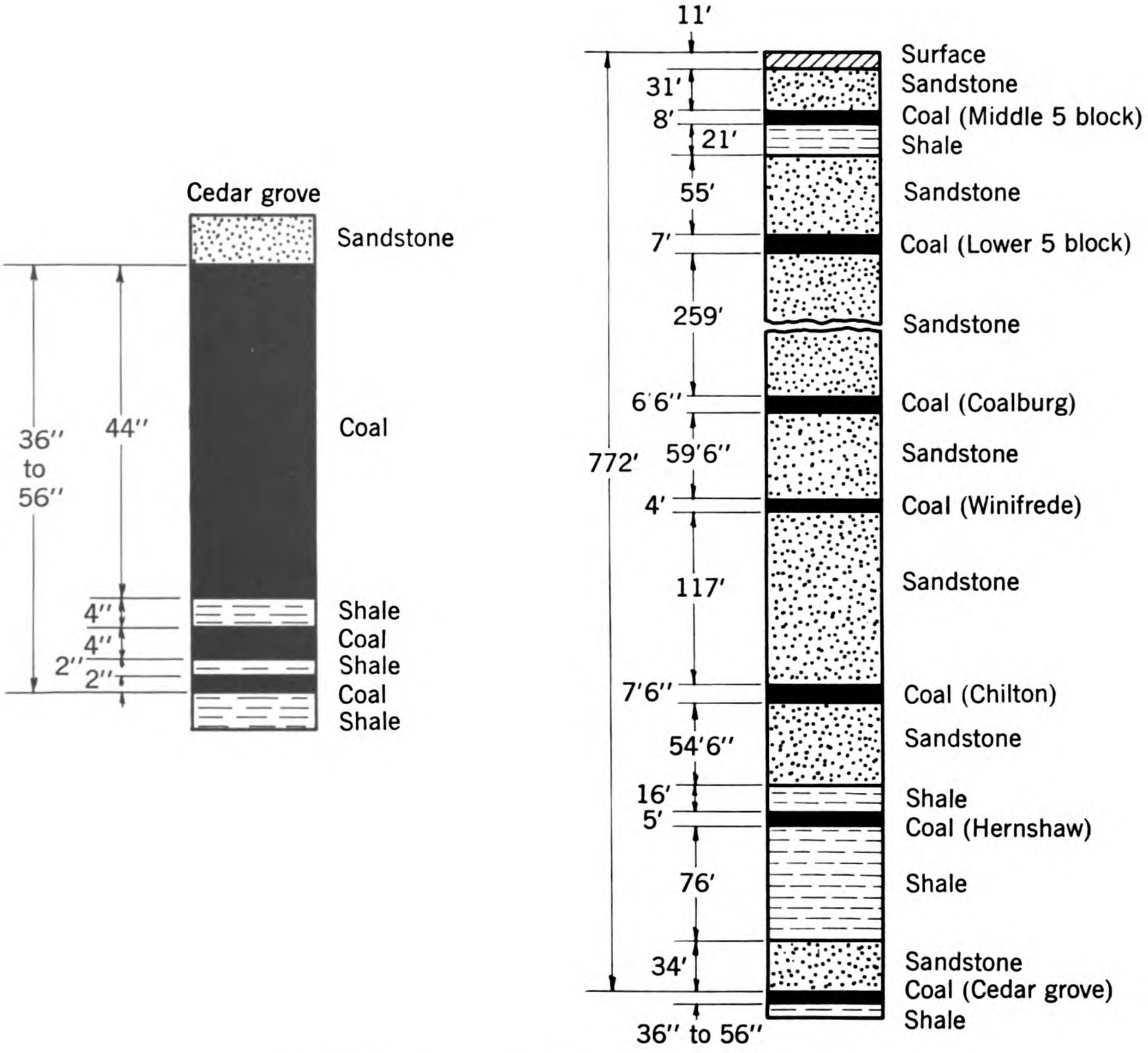

FIGURE 5. - Section of Coalbed and Overburden at Mine 3.

brushed in the No. 3 main entry to provide at least 50 inches of headroom over the rail.

Panel entries 26 feet wide in sets of four are turned 90 degrees from the mains about 600 feet between panel centers and are driven 2,000 feet. Crosscuts are driven 12 to 16 feet wide on 50- and 100-foot centers.

Two mobile-loading units are used to advance a set of main and panel entries. (See fig. 6.) Each unit consists of 8-1/2 men (on the basis of assigned time per shift); one loading machine; two bridge conveyors; two chain conveyors, each 300 feet long; one chain conveyor 108 feet long; two shortwall cutting machines; and two handheld electric drills. A three-wheel supply

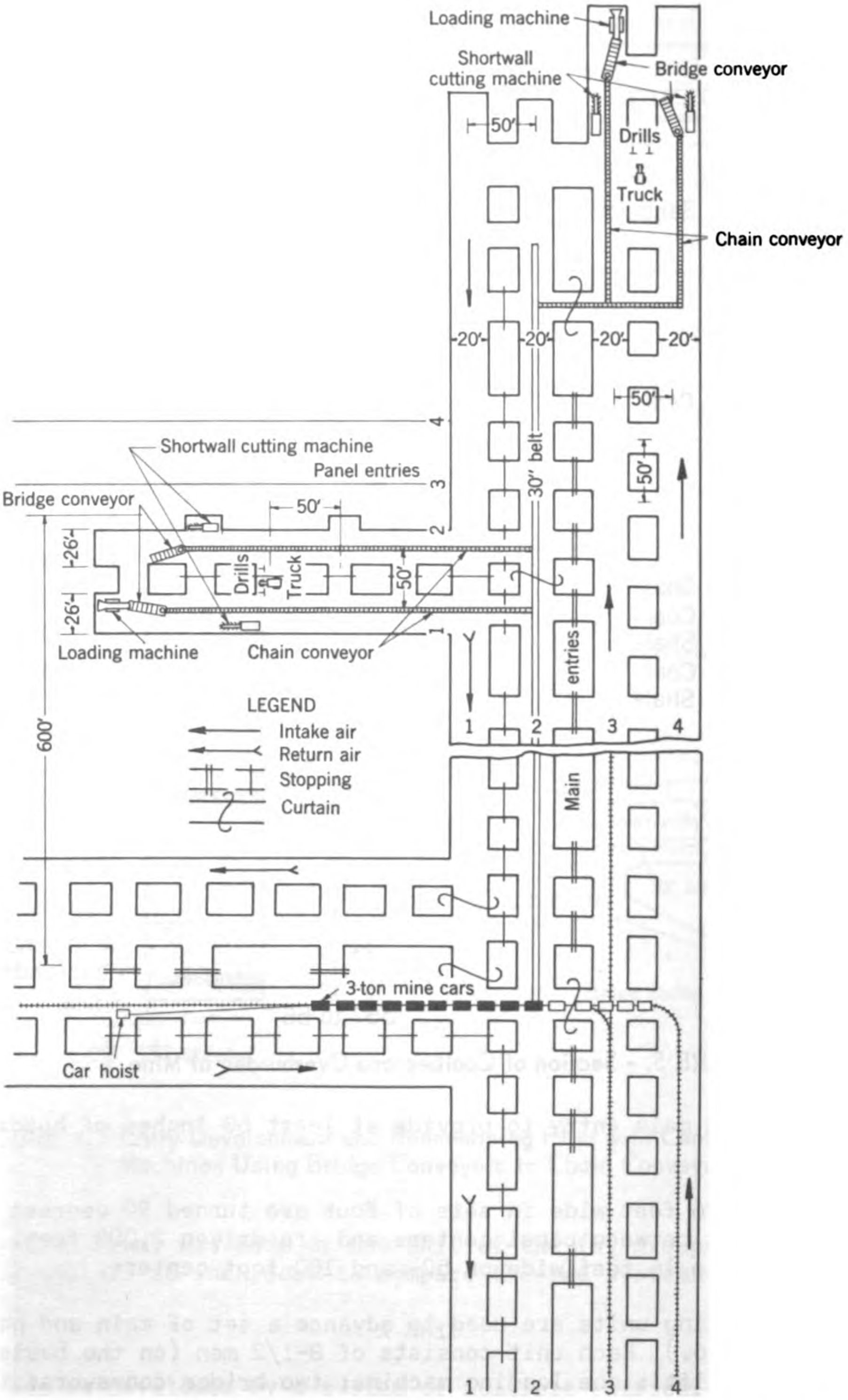

FIGURE 6. - Main and Panel-Entry Development Plan with Mobile-Loading Equipment Using Bridge to Chain Conveyors at Mine 3.

truck, a 30-inch belt 2,000 feet long, and a car hoist serve two units. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and by machine on the third shift.

c The cycle of operation is: Timber, rock dust, drill, cut, pan up, blast, and load coal. Panel entries are timbered with posts set on 4-foot centers and in three rows set 5, 10 (along conveyor line), and 21 feet from the left rib in No. 1 and No. 3 entries, but timbered from the right rib in No. 2 and No. 4 entries. Crosscuts are timbered with posts set on 4-foot centers in two rows, each set 3 feet from the rib. Wood crossbars 6 by 8 inches by 16 feet long on 4-foot centers are set when required.

Entries are advanced in pairs for 300 feet, and the equipment then is moved to the next pair of entries. Entries are bottom cut, and five blast holes 8 to 8-1/2 feet deep are drilled. The holes are set 8 inches below the roof and 3 feet from either rib on 5-foot centers, are charged with two to three sticks of permissible powder, and are detonated simultaneously.

The mined coal is loaded by a mobile-loading machine to a bridge conveyor that discharges coal to a chain conveyor, then to a 30-inch belt that transports and loads the coal into 3-ton steel bottom-dump mine cars. A car hoist is used to spot the empty cars at the belt head. No. 3 entry is bottom brushed to 50 inches over the rail for headroom.

The average advance of each entry or entry and crosscut is 21 feet per shift or 84 feet for a set of entries. A unit produces 137 tons of raw coal per shift and yields 120 tons of clean coal. This is 16.1 tons of raw coal or 14.1 tons of clean coal for each man in the unit crew.

A mobile-loading bridge and chain conveyor unit crew consists of:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.......................... | Full-time |
| 1 Loading-machine operator................. | Do. |
| 1 Loading-machine operator's helper....... | Do. |
| 1 Cutting-machine operator................. | Do. |
| 1 Cutting-machine operator's helper....... | Do. |
| 2 Drillers and shotfirers.................. | Do. |
| 1 Pan man.................................. | Do. |
| 1 Beltman.................................. | 1/2 |
| Total.................. 9 men working | 8-1/2 shifts |

Face-haulage delays (27 minutes) were: Connecting bridge conveyor, 12 minutes; mechanical (bridge conveyor), 11 minutes; and aligning conveyor, 4 minutes. Production delays (62 minutes) were: Tramming loading machine, 33 minutes; mechanical, 10 minutes; greasing, 10 minutes; and waiting on coal, 9 minutes. Other delays (47 minutes) resulted from timbering, 3 minutes; handling supplies, 8 minutes; and waiting on empties, 36 minutes. Travel time required 60 minutes, and lunch was staggered, leaving 420 minutes for face-work time. The total delay at the face was 136 minutes, allowing 284 minutes' productive work time per shift.

## B Unit

Rooms are driven in pairs 250 feet deep, 40 feet wide on 50-foot centers with crosscuts 16 feet wide on 50-foot centers. (See fig. 7.) The unit consists of nine men; one loading machine; two shortwall cutting machines; two handheld electric drills; two chain conveyors, each 300 feet long; a 30-inch

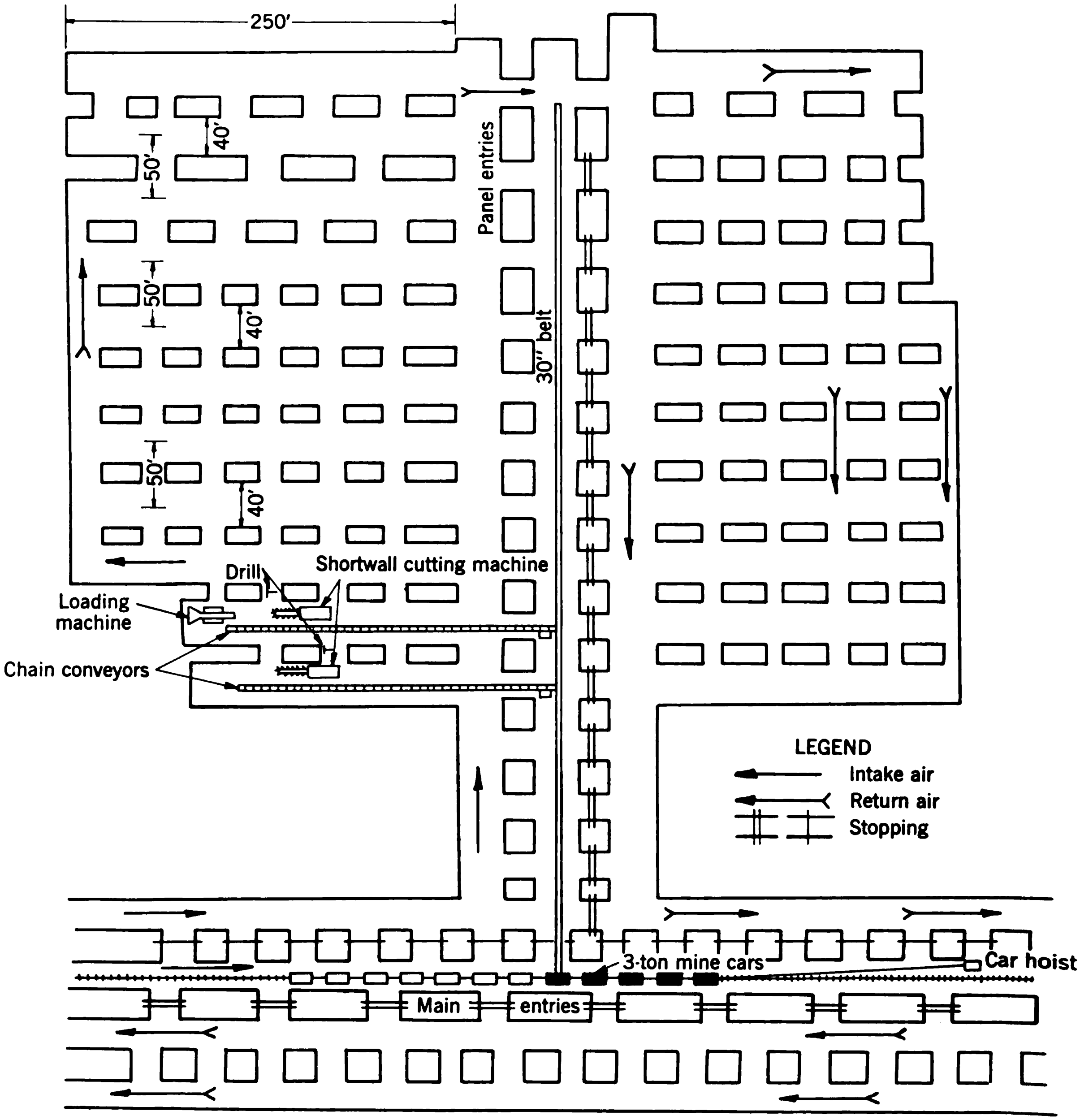

FIGURE 7. - Room-Mining Plan with Mobile-Loading Equipment Using Chain Conveyors at Mine 3.

belt; and a car hoist. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and by machine on the third shift.

The cycle of operation is: Timber, rock dust, drill, cut, pan up, blast, and load coal. Rooms are timbered with posts set on 4-foot centers in four rows 8 and 10 feet from the left rib to the chain conveyor, and 8 and 10 feet from the right rib to the chain conveyor. Crosscuts are timbered with two rows of posts, each row 3 feet from the ribs and the posts on 4-foot centers. Wood crossbars 6 inches by 8 inches by 16 feet long on 4-foot centers are set when required. Rooms are bottom cut, and the face is drilled with eight blast holes 8 to 8-1/2 feet deep. The holes are set 8 inches below the roof and 2-1/2 feet from either rib on 5-foot centers. Each hole is charged with two to three sticks of permissible powder and is detonated simultaneously.

The mined coal is loaded by a mobile-loading machine on to the chain conveyor which discharges coal to a 30-inch belt and then into 3-ton steel bottom-dump mine cars. The cars are moved and spotted at the belt head with a car hoist.

The average advance of each room or room and crosscut is 11.5 feet per shift or 23 feet of advance for two rooms. A unit produces 172 tons of raw coal per shift and yields 150 tons of clean coal. This is 19.1 tons of raw coal or 16.7 tons of clean coal for each man in the unit crew. The unit crew comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.................................... | Full-time |
| 1 Loading-machine operator.......................... | Do. |
| 1 Loading-machine operator's helper................. | Do. |
| 1 Cutting-machine operator.......................... | Do. |
| 1 Cutting-machine operator's helper................. | Do. |
| 2 Drillers and shotfirers........................... | Do. |
| 1 Pan man........................................... | Do. |
| 1 Beltman........................................... | Do. |
| Total............................ 9 men working | 9 shifts |

Face-haulage delays to align the conveyor took 15 minutes. Production delays (87 minutes) were due to tramming loading machine, 14 minutes; greasing, 16 minutes; and waiting on coal, 57 minutes. Other delays (72 minutes) were for timbering, 17 minutes; trimming roof, 7 minutes; handling supplies, 2 minutes; and waiting on empties, 46 minutes. Travel time required 36 minutes, and lunch took 30 minutes, leaving 414 minutes for face work time. The total delay at the face was 174 minutes, allowing 240 minutes of productive time per shift.

## Mine 4

This mine is operated in the Pittsburgh (No. 8) bed which averages 55 inches thick in the area. The bed is flat-lying with some local dips. A shale parting 1 inch thick occurs 12 inches above the bottom of the bed. (See fig. 8.) The bed is underlain by fire clay and overlain by 12 inches of draw slate, above which is 6 inches of top coal. The overburden consists mainly of shales and limestones and averages 274 feet thick.

Loaded mine cars are hauled by 6-ton locomotives in seven car trips over 42-inch gage (65-pound rail) track to a rotary dump at the foot of the slope. The slope is 700 feet long on a pitch of 16 degrees 30 minutes and is equipped with a supply track and a 36-inch belt for transporting the coal to the preparation plant.

The mine is operated three shifts per day and produces an average of 4,267 tons of raw coal that yields 3,840 tons of clean coal with the following units:

(a) 2 ripper-type continuous-mining units, each with an extensible belt to mine rooms; 6 men in each unit; 6 unit shifts per day;

(b) 1 ripper-type continuous-mining unit with 2 shuttle cars to develop butt entries; 7 men in each unit; 3 unit shifts per day;

(c) 1 ripper-type continuous-mining unit with 2 shuttle cars to mine rooms; 7 men in each unit; 3 unit shifts per day;

(d) 2 ripper-type continuous-mining units, each with 2 shuttle cars to develop main entries; 8 men in each unit; 6 unit shifts per day.

To compare the three systems of face haulage, the Bureau made a detailed study of the two continuous-mining units (a) with extensible belts in rooms; the continuous-mining unit (b) with shuttle cars in butt entries; and the continuous-mining unit (c) with shuttle cars in rooms.

### Extensible Belt Haulage in Rooms

Rooms are driven as the butt entries advance. The two outby rooms off the inby entry are mined simultaneously to the projected limit (300 or 600 feet), and then one room at a time is mined to complete the side of the panel. On completion of these rooms, the two inby rooms off the outby entry are mined to the projected limit and then one room at a time is mined to complete the mining of that side of the panel. Rooms are driven 300 and 600 feet long and 16 feet wide on 32-foot centers with crosscuts 8 to 12 feet wide on 40- and 60-foot centers. (See fig. 9.)

A continuous-mining unit consists of six men, a ripper-type continuous-mining machine, a 24-inch extensible belt, a pressure pump for supplying water for sprays on continuous-mining machine, and a 30-inch belt. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done between shifts by the supply men.

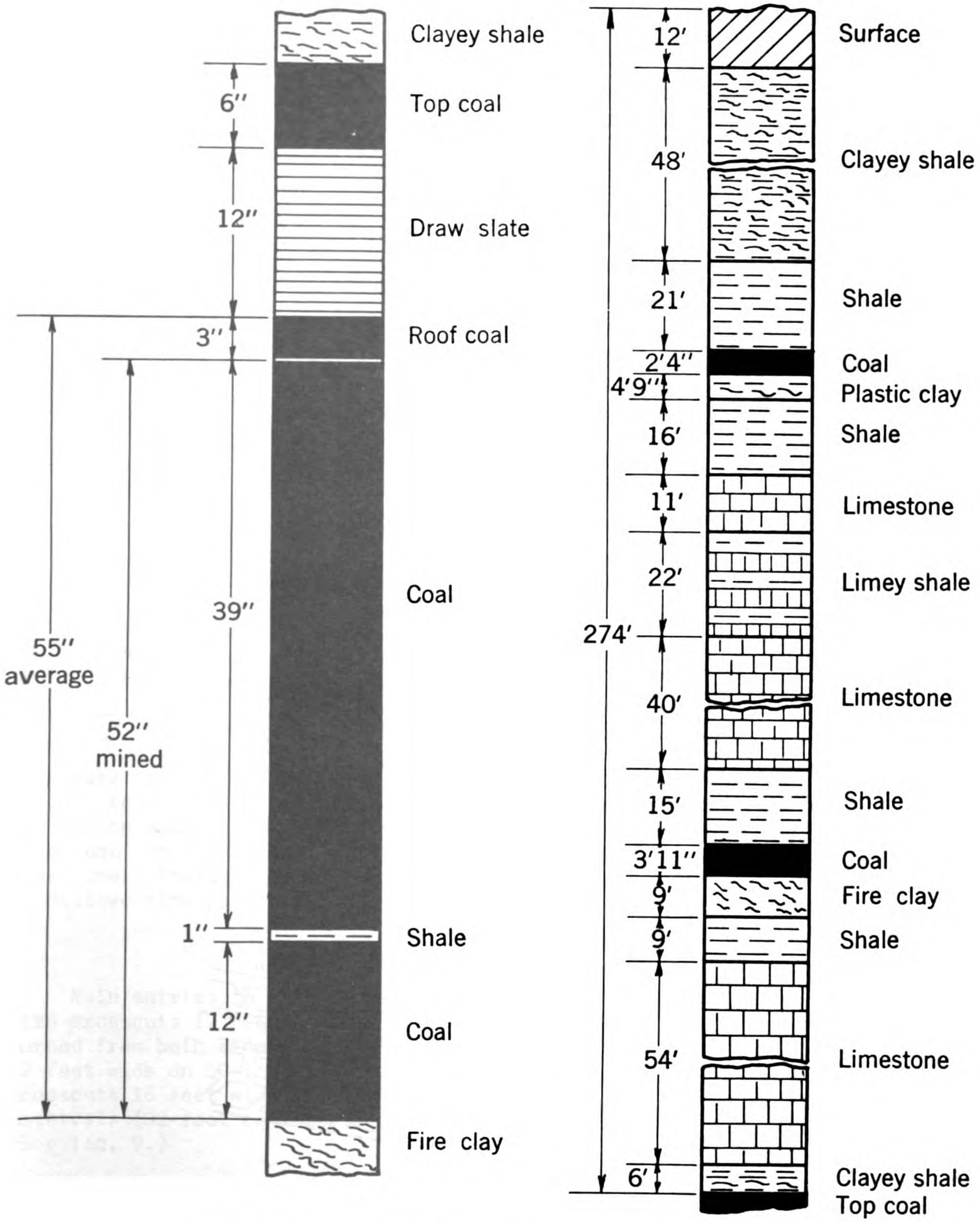

**FIGURE 8. - Section of Coalbed and Overburden at Mine 4.**

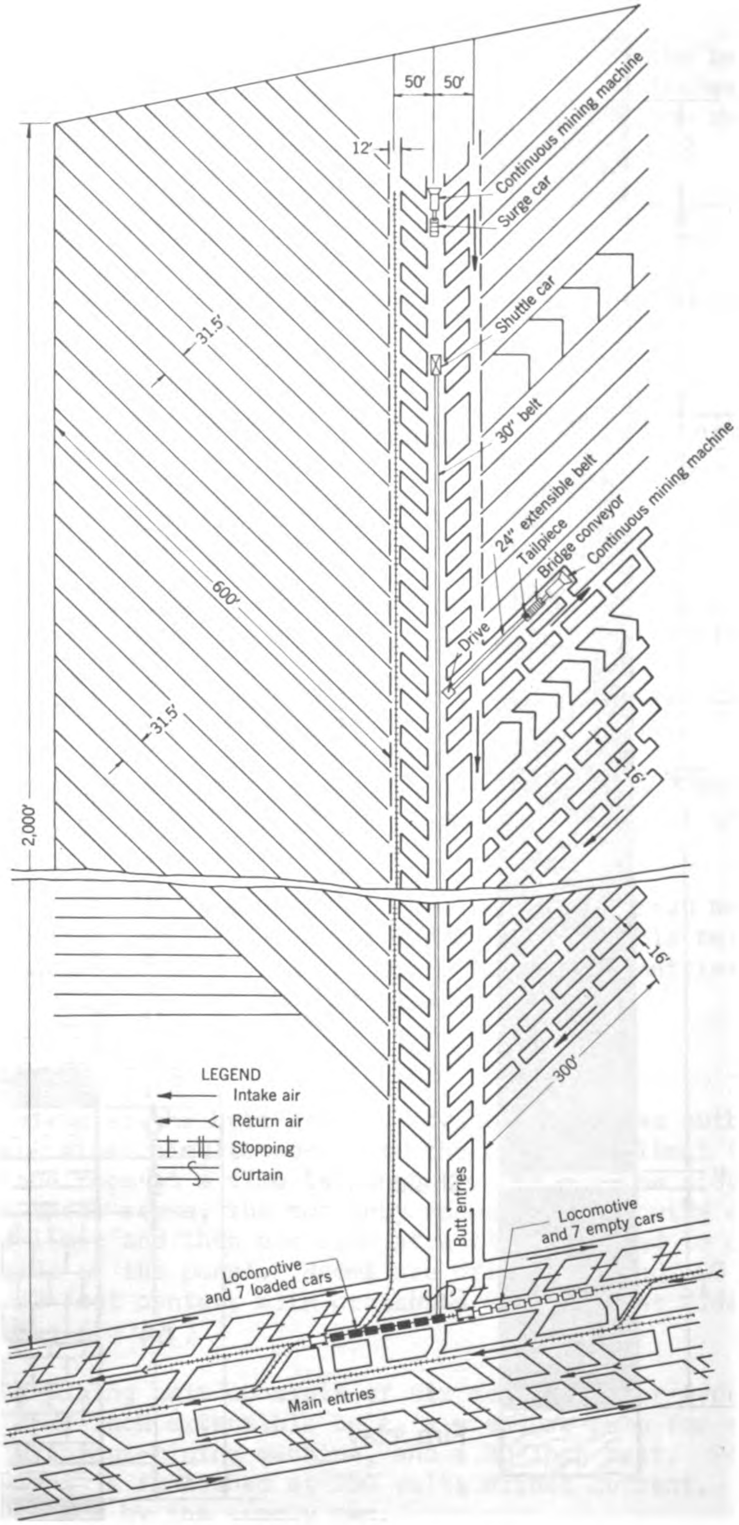

FIGURE 9. - Butt-Entry-Development Plan with a Continuous-Mining Machine Using a Surge and Shuttle Car and Room-Mining Plan with a Continuous-Mining Machine Using an Extensible Belt at Mine 4.

About 3 inches of top coal is left to prevent deterioration of the draw slate. Rooms are timbered with 12-foot long steel crossbars (60-pound rail and 4-inch H-beams) set on wood posts and spaced on 4-foot centers. The crossbars are raised and held to the roof by hydraulic jacks on the continuous-mining machine until a wood post is placed under each end by the timbermen. All roof supports in rooms are recovered. As mining progresses, the last completed room is maintained as a travelway, and timbers in the next adjacent room are recovered by one supply man, are loaded into a shuttle car, and are distributed at the crosscuts of the last completed room. As the continuous-mining machine advances, the tailpiece of the extensible belt is advanced also by a crew member, usually the mechanic. The mined coal is transferred from the extensible belt to the 30-inch panel belt that also serves the shuttle-car unit. Rock dusting is done by hand between shifts.

The average advance in rooms is 85 feet, and in crosscuts it is 32 feet or the equivalent of 109 feet of working place 16 feet wide per shift. A unit produces 324 tons of raw coal or 292 tons of clean coal per shift. This is 54.0 tons of raw coal or 48.7 tons of clean coal per shift for each man in the unit crew, which consists of the following:

| CLASSIFICATION: | | Assigned time per shift |
|---|---|---|
| 1 Section foreman | | 1/2 |
| 1 Continuous-mining machine operator | | Full-time |
| 2 Timbermen | | Do. |
| 1 Supply man | | Do. |
| 1 Mechanic | | Do. |
| 1 Belt operator[1] | | 1/2 |
| Total | 7 men working | 6 shifts |

[1] Not considered member of crew by company.

Face haulage delays (5 minutes) were for extending the extensible belt. Production delays (25 minutes) were due to waiting for coal from the continuous-mining machine. Other delays (60 minutes) were waiting on empties. Travel time required 60 minutes, and lunch took 30 minutes, leaving 390 minutes for face time. The total delay at the face was 90 minutes, allowing 300 minutes' productive time per shift.

## Shuttle Car Haulage in Entries

Main entries in sets of five are driven 12 feet wide on 50-foot centers with crosscuts 12 feet wide as projected. Butt entries in sets of three are turned from both sides of the mains on 550- or 750-foot centers and are driven 12 feet wide on 50-foot centers to depths ranging from 1,700 to 2,000 feet. Crosscuts 16 feet wide are turned 45 degrees from the center entry at 45-foot intervals (32-foot centers) and are staggered to the left and to the right. (See fig. 9.)

A butt entry unit consists of seven men, one ripper-type continuous-mining machine, two shuttle cars (one used as a surge car), one pressure pump for supplying water for sprays on continuous-mining machine, a 30-inch belt, and supply track. Power to operate the equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and between shifts.

About 3 inches of top coal is left to protect the draw slate which weathers and falls after exposure. Entries are timbered with 12-foot long steel crossbars (60-pound rail) set on wood posts and spaced on 4-foot centers. Roof supports are recovered as room mining retreats. A continuous-mining machine operates from the center entry driving crosscuts alternately to the left and to the right at 22-1/2-foot intervals 45 degrees to either outside entry and then advancing the outside entry to the next room neck. The machine then is retreated, the center entry is advanced to the next crosscut to the opposite side, and the procedure just described is repeated. Rock dusting is done by hand between shifts.

The continuous-mining machine transfers the mined coal to a surge car (shuttle car) which in turn loads into a 3-ton capacity shuttle car. The shuttle car end-loads a 30-inch belt which transfers the coal to 5-ton capacity steel bottom-dump mine cars.

The average advance of each entry or entry and crosscut is 29 feet per shift or about 87 feet for the three entries with crosscuts. A unit produces 170 tons of raw coal per shift and yields 153 tons of clean coal. This is 24.3 tons of raw coal or 21.9 tons of clean coal per shift for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | | Assigned time per shift |
|---|---|---|
| 1 Section foreman | | 1/2 |
| 1 Continuous-mining machine operator | | Full-time |
| 2 Timbermen | | Do. |
| 1 Surge-car operator | | Do. |
| 1 Shuttle-car operator | | Do. |
| 1 Mechanic | | Do. |
| 1 Belt operator[1] | | 1/2 |
| Total | 8 men working | 7 shifts |

[1] Not considered member of crew by company.

No delays were charged to shuttle cars in face haulage. Production delays (26 minutes) consisted of waiting for coal from the continuous-mining machine. Other delays were delivery of supplies, 10 minutes, and waiting on empties, 60 minutes, or a total of 70 minutes. All delays amounted to 96 minutes. Travel time required 60 minutes, and lunch took 30 minutes, leaving 390 minutes for face time. The total delay at the face was 96 minutes, allowing 294 minutes' productive time.

### Shuttle Car Haulage in Rooms

Three butt entries are driven 12 feet wide on 35-foot centers to a depth of 1,700 feet. Crosscuts are turned at 45 degrees from the center entry alternately to the left and to the right and are driven 16 feet wide. (See fig. 10.) Rooms are extensions of the crosscuts and are driven as the butt

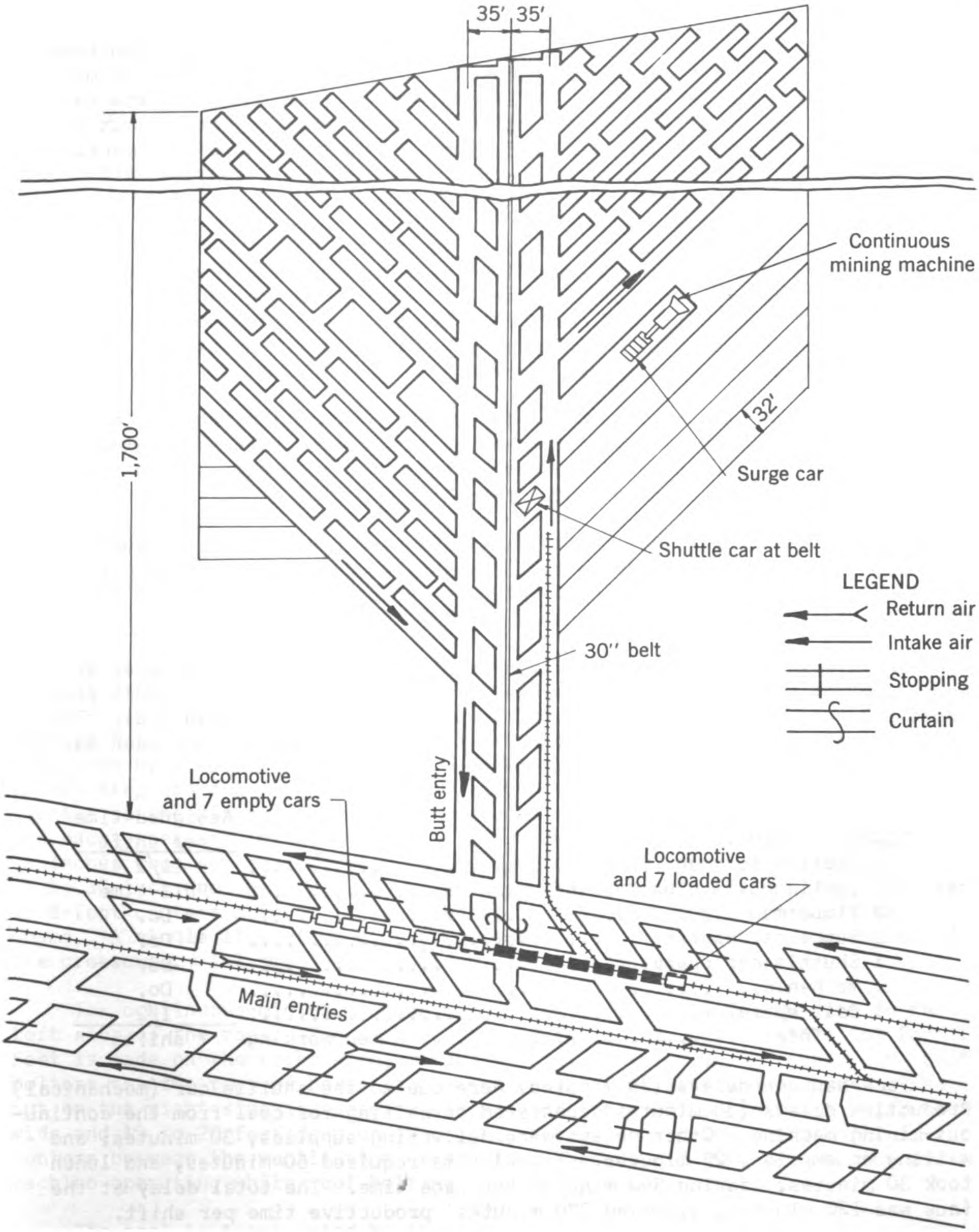

FIGURE 10. - Room-Mining Plan with a Continuous-Mining Machine Using a Surge and Shuttle Car at Mine 4.

entries advance. The two outby rooms on the inby entry are mined simultaneously to the projected limit (300 feet) and then one room at a time is mined to complete that side of the panel. On completion of these rooms, the two inby rooms on the outby entry are mined together to the projected limit and then are mined one room at a time to complete the outby side of the panel. Rooms are driven 300 feet long and 16 feet wide on 32-foot centers with crosscuts 8 to 12 feet wide on 40- and 60-foot centers.

A continuous-mining unit consists of seven men, one ripper-type continuous-mining machine, two shuttle cars (one used as a surge car), one 3-wheel utility cart, one pressure pump for water sprays on the continuous-mining machine, one 30-inch belt, and one supply track. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done between shifts by one of the crew members.

About 3 inches of top coal is left to prevent deterioration of the draw slate. Rooms are timbered with 12-foot long steel crossbars set on wood posts and spaced on 5-foot centers. All roof supports in the rooms and in the entries are recovered as room mining retreats.

The continuous-mining machine transfers the mined coal to the surge car which in turn loads into a 3-ton capacity shuttle car. The shuttle car end loads a 30-inch belt in the center entry which transfers the coal to 5-ton capacity steel bottom-dump mine cars.

The average advance is 70 feet in rooms and 32 feet in crosscuts, or the equivalent of 94 feet of working place 16 feet wide per shift. A unit produces 267 tons of raw coal per shift, yielding 240 tons of clean coal. This is 38.1 tons of raw coal or 34.3 tons of clean coal per shift for each man in the crew, which consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | 1/2 |
| 1 Continuous-mining machine operator | Full-time |
| 2 Timbermen | Do. |
| 1 Surge-car operator | Do. |
| 1 Shuttle-car operator | Do. |
| 1 Mechanic | Do. |
| 1 Belt operator | 1/2 |
| Total 8 men working | 7 shifts |

Face-haulage delays (35 minutes) were due to the shuttle car (mechanical). Production delays (30 minutes) consisted of waiting for coal from the continuous-mining machine. Other delays were delivering supplies, 30 minutes; and waiting on empties, 25 minutes. Travel time required 60 minutes, and lunch took 30 minutes, leaving 390 minutes for face time. The total delay at the face was 120 minutes, allowing 270 minutes' productive time per shift.

## Mine 5

This mine is operated in the Pittsburgh No. 8 bed which averages 54 inches thick in this area. A pyritic and a shale parting, each one-half inch thick, occur 29 and 32-1/2 inches above the bottom of the bed. (See fig. 11.) The bed is underlain by fire clay and overlain by 12 inches of draw slate, above which is 8 to 14 inches of top coal. The overburden consists mainly of shales and limestones and averages 95 feet thick.

The mine is operated two shifts per day and one unit (a) produces an average of 600 tons of raw coal.

The mine was opened in a strip mine that left an island of coal 300 to 1,000 feet wide between the highwalls.

Single rooms 16-1/2 feet wide and 450 to 500 feet deep are driven from the highwall. Crosscuts 9-1/2 feet wide on 80-foot centers are driven on 45 degrees for ventilation. Blind crosscuts are driven on 20-foot centers. (See fig. 12.)

The continuous-mining unit consists of seven men, one continuous-mining machine, one extensible belt conveyor, one roof-bolting machine, and a blowing fan. Power to operate the machines is furnished at 250 volts direct current by a diesel generator set on the surface.

About 2 inches of coal is left to keep the draw slate from falling and contaminating the mined coal. The first 40 feet of the room are supported with 4-inch steel H-beams 14 feet long set 3 to 4 feet apart. One end of the beam is set in a hitch in the left rib at the roof line, and the other end is supported by a wood post. Hitches 5 inches high, 12 inches wide, and 18 inches deep are dug with a hydraulic digger mounted on the continuous-mining machine as the mining advances. Three rows of bolts set 4 feet from the ribs and each other are installed. Bolts are 5/8-inch expansion shell type, 90 and 96 inches long set against 6- by 6- by 1/4-inch steel-bearing plates on 2- by 9- by 30-inch wood headers. Four-inch aluminum H-beams, 15 feet long, are set on 8-foot centers between lines of bolts in a similar manner as the steel beams. A single line of wood posts on 4-foot centers is set in the center of the crosscuts. All steel and aluminum H-beams are recovered.

The continuous-mining machine makes a 9-1/2-foot cut for 20 feet on the left side of the room. The machine then is retracted, and a 7-foot cut for 20 feet is made on the right side, making a total width of 16-1/2 feet. The roof bolters set two rows of bolts in the cut on the left side and one row in the cut on the right side as these cuts are completed. Blind crosscuts 9-1/2 feet wide and 15 to 20 feet deep on 45 degrees are driven to the right on 20-foot centers between the ventilating crosscuts. These are driven to keep the mining machine operating while roof bolting is proceeding.

The coal is transported by the extensible belt to the surface to the two tandem elevating conveyors which discharge into diesel-powered 30-ton capacity bottom-dump trucks. Two trucks are used on each shift and transport the coal to a central tipple.

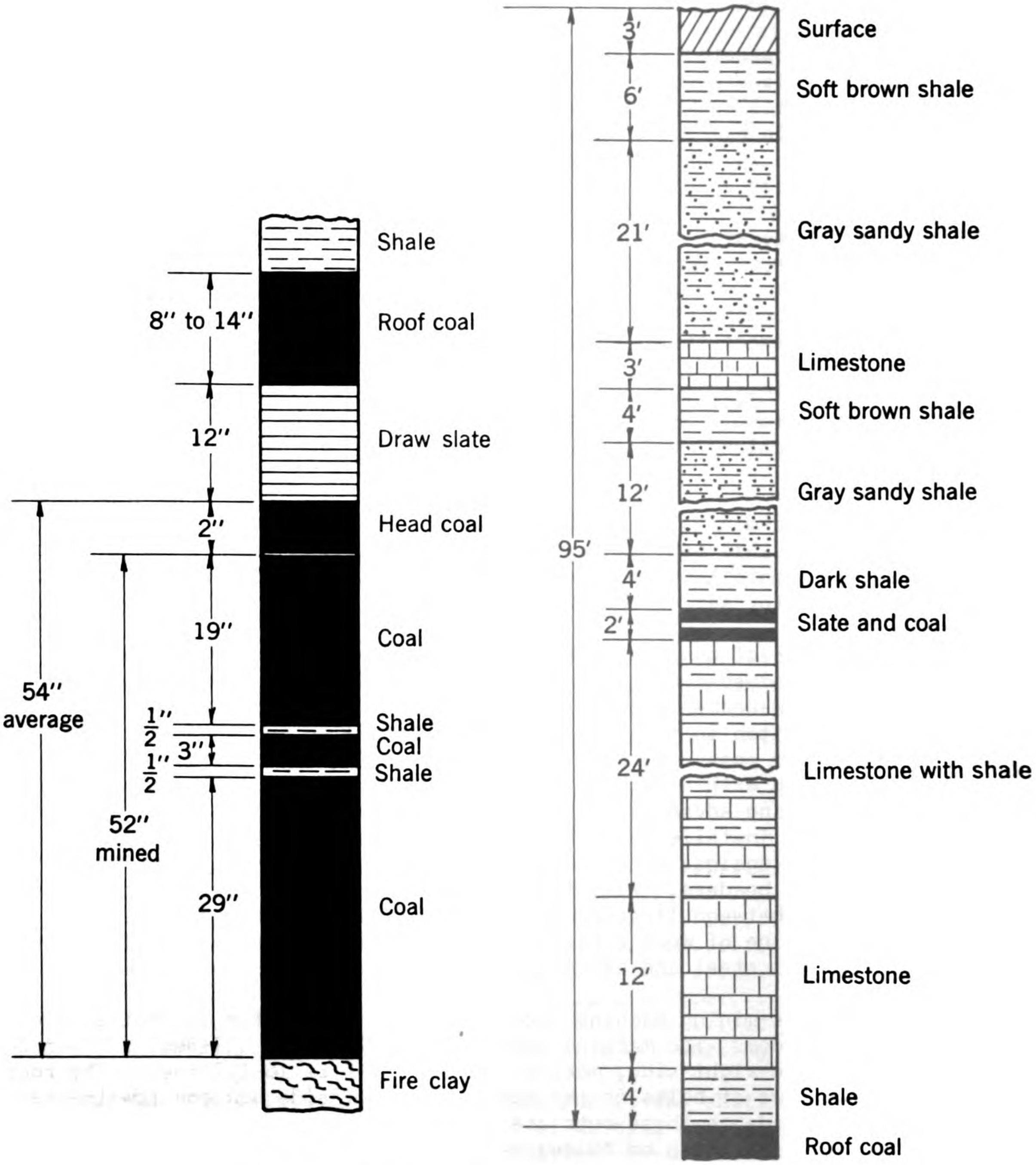

FIGURE 11. - Section of Coalbed and Overburden at Mine 5.

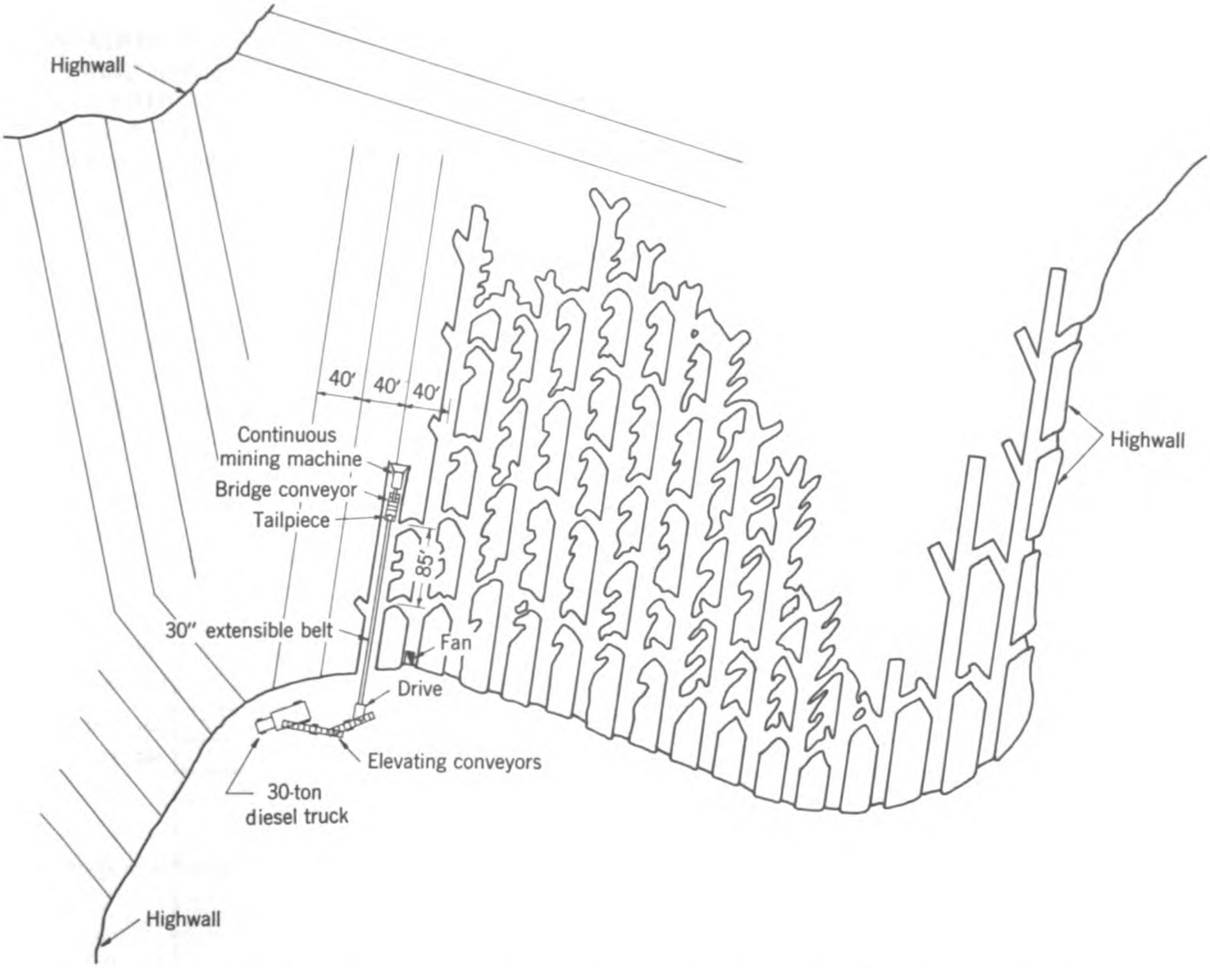

FIGURE 12. - Room-Mining Plan with a Continuous-Mining Machine Using an Extensible Belt at Mine 5.

The average advance of the continuous-mining machine in a room 16-1/2 feet wide is 65 feet per shift plus 80 feet per shift in crosscuts 9-1/2 feet wide. A unit produces 300 tons of raw coal per shift or 42.9 tons per man in the unit crew, which comprises the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.................................... | Full-time |
| 1 Continuous-mining machine operator................ | Do. |
| 1 Continuous-mining machine operator's helper....... | Do. |
| 2 Roof bolters....................................... | Do. |
| 1 Timberman.......................................... | Do. |
| 1 Mechanic........................................... | Do. |
| Total........................... 7 men working | 7 shifts |

Face-haulage delays (14 minutes) resulted from extending the extensible belt, 5 minutes; and moving to a new room location, 9 minutes. Production delays (60 minutes) involved waiting for coal from the continuous-mining machine. Other delays (60 minutes) were timbering (roof bolting) and delivery of supplies. No travel time was required, and lunch took 30 minutes, leaving 450 minutes for face time. The total delay at the face was 134 minutes, allowing 316 minutes' productive time per shift.

## Mine 6

The mine is operated in the Upper Freeport coalbed which ranges from 42 inches in thickness in the newly-developed areas to 98 inches in the older mining areas. A bony coal parting 3 inches thick occurs at the top of the bed in the thin coal area, and a shale parting 3 inches thick and a bony coal parting 10 inches thick occur 7 and 55 inches above the bottom in the thick coal area. (See fig. 13.) The bed is overlain by shale, and the overburden consists of sandy shales, clayey shales, sandstones, and a coalbed, and averages 300 feet in thickness. The coal bed is underlain by fire clay 4 to 6

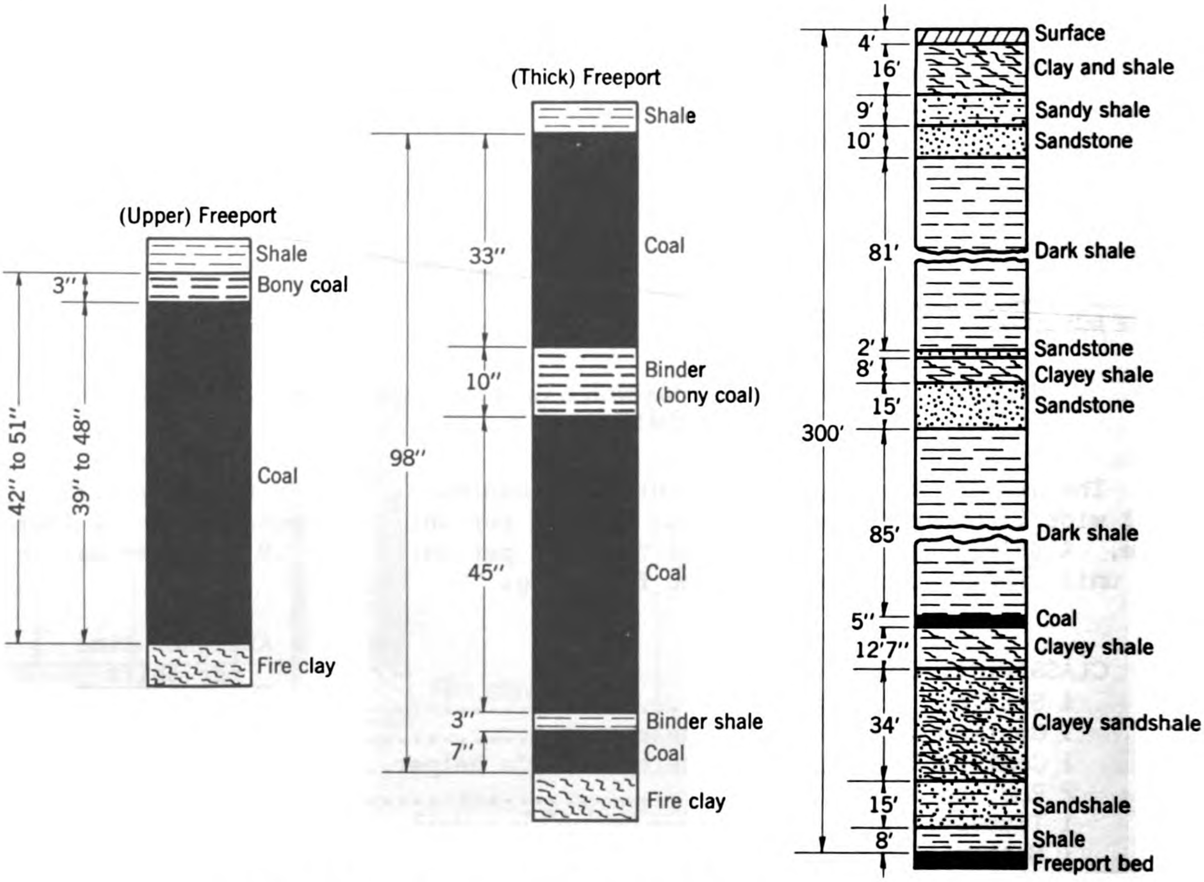

FIGURE 13. - Section of Coalbed and Overburden at Mine 6.

feet thick. Clay veins and rolls are encountered in mining, and the bed has a regional dip of 1-1/2 percent to the southeast. Pillars are extracted on retreat.

The loaded mine cars are transported in 25 car trips by two 15-ton locomotives in tandem over 44-inch gage (60-pound rail) track to a rotary dump at the foot of a vertical hoisting shaft. The coal is fed automatically into two 8-ton capacity skips hoisted to the surface and is conveyed to the preparation plant. A supply slope 540 feet long on 18 degrees and a 20-minute dip is used to deliver supplies and mining equipment to the mine. Men enter and leave the mine by elevator through a vertical shaft 301 feet deep.

The mine is operated three shifts per day and produces an average 4,231 tons of raw coal that yields 4,200 tons of clean coal with the following units:

(a) 4 ripper-type continuous-mining units, each with shuttle-car haulage discharging into mine cars to develop entries and extract pillars; 7-1/2 men in each unit (on the basis of assigned time per shift); 12 unit shifts per day;

(b) 2 ripper-type continuous-mining units, each with shuttle-car haulage discharging onto 30-inch belts to develop entries, mine rooms, and extract room and entry pillars; 6-5/6 men in each unit (on the basis of the assigned time per shift); 6 unit shifts per day;

(c) 2 mobile-loading units, each with shuttle-car haulage discharging into mine cars to develop entries and extract pillars; 8 men in each unit; 6 unit shifts per day;

(d) 3 track-mounted units to develop entries and extract pillars; 8-1/3 men in each unit (on the basis of assigned time per shift); 9 unit shifts per day.

A detailed study was made of the four varied types of face transportation in entry development and room mining to compare the different systems of face haulage.

### Shuttle Car to Mine Car Haulage

The mine is developed by a system of multiple entries. Main and cross mains are driven 13 feet wide in sets of seven on 50-foot centers with crosscuts 13 feet wide turned on angles of 60 and 90 degrees on 100-foot centers or as projected. The bottom is brushed where required to provide 6 feet of headroom over the rail in track entries.

Butt entries 16 feet wide in sets of four on 100-foot centers are turned 90 degrees from the mains on 500-foot centers and are driven 2,000 feet. Crosscuts are driven 16 feet wide and are turned on an angle of 80 to 90 degrees on 100-foot centers.

A continuous-mining unit is used to advance a set of entries. (See fig. 14.) Each unit consists of 7-1/2 men (on the basis of time assigned per unit), a continuous-mining machine, a loading machine, two shuttle cars (one spare), one rotary roof-bolting machine with dust collector or stoper with dust collector, and one 8-ton locomotive. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine between shifts and on weekends.

The cycle of operations is: Set safety posts, roof bolt, rock dust, and ripper cut and load coal.

Entries are roof bolted with 5/8-inch expansion shell-type bolts 48 inches long set on the center and 3-1/2 feet on each side of center in rows 4 feet apart. The bolts are set against 6- by 6- by 1/4-inch steel plates.

Entries are advanced in pairs. A ripper-type continuous-mining machine advances a 16-foot wide entry for 16 feet and then is retracted and is moved to advance a crosscut, if available, or to the other entry to allow the 16-foot advance to be roof bolted. This is repeated until the pair of entries has advanced 200 feet (two crosscuts), after which the continuous-mining unit is retracted and moved to the other two entries which are advanced in a similar manner.

The coal is mined and deposited on the bottom from where it is loaded by a loading machine into a shuttle car. The shuttle car transports the coal to a loading ramp and unloads it into 8-ton capacity steel mine cars. Cars are spotted and moved at the loading ramp by an 8-ton locomotive. A new loading ramp location is established every 200 feet of advance.

The average advance of each entry or entry and crosscut is 7.5 feet per shift or 30 feet per shift for the group. Each unit produces 114 tons of raw coal per shift, yielding 113.7 tons of clean coal. This is 15.2 tons of raw coal or 15.1 tons of clean coal per shift for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | | Assigned time per shift |
|---|---|---|
| 1 Section foreman | | 1/2 |
| 1 Continuous-mining machine operator | | Full-time |
| 1 Loading-machine operator | | Do. |
| 2 Roof bolters | | Do. |
| 1 Shuttle-car operator | | Do. |
| 1 Mechanic | | Do. |
| 1 Motorman | | Do. |
| Total | 8 men working | 7-1/2 shifts |

Face-Haulage delays were 40 minutes for mechanical failures of the shuttle car. Production delays were 143 minutes for mechanical failure and maneuvering of the continuous-mining machine. Other delays were 40 minutes for waiting on empties. Travel time required 62 minutes, and lunch took 30 minutes, leaving 388 minutes for face time. Total face delays were 223 minutes, allowing 165 minutes' productive time per shift.

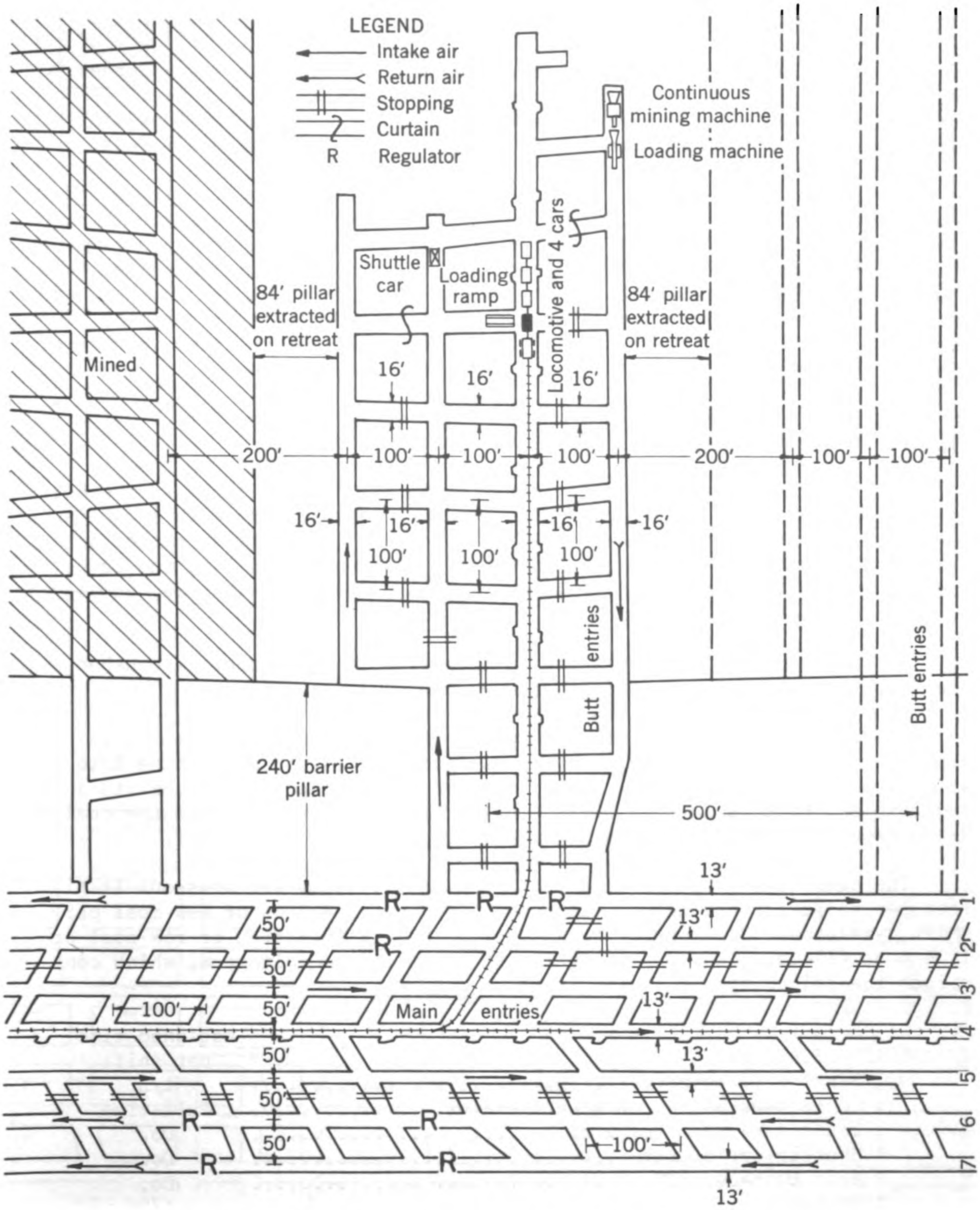

FIGURE 14. - Entry-Development Plan with a Continuous-Mining Unit Using a Loading Machine and Shuttle Car at Mine 6.

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## Shuttle Car to Belt Haulage

Butt entries 16 feet wide in sets of 4 on 50-foot centers are turned 90 degrees from the mains on 800-foot centers and are driven 2,000 feet. From both sides of the entries, rooms are turned 16 feet wide on 100-foot centers with crosscuts 16 feet wide on 100-foot centers and are driven 320 feet.

A continuous-mining unit is used to advance a set of butt entries and rooms from both sides and to extract entry and room pillars on retreat. (See fig. 15.) Each unit consists of 6-5/6 men (on the basis of assigned time per shift), one ripper-type continuous-mining machine, one loading machine, two shuttle cars (one spare), one stoper, one 30-inch belt, one car spotter, and one air compressor that also serves another unit. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine between shifts and on weekends.

The cycle of operations is: Set safety posts, roof bolt, rock dust, and ripper cut and load coal.

Entries, rooms, and pillar splits are roof bolted similarly to the bolting pattern described in the previous butt-entry development with a continuous-mining unit. Entry-and-room advance are conducted in a similar manner as described previously. In extraction after splitting the pillar, the pocket-and-fender method of mining is employed. The fender, 10 feet wide, usually is recovered on retreat. (See room 29, fig. 15.)

The coalbed is 51 inches thick in this area, and the roof is brushed in the track entry to provide 6 feet of headroom over the rail.

The coal is mined by a ripper-type continuous-mining machine and is deposited on the bottom from where it is loaded by a loading machine into a 4-1/2-ton capacity shuttle car. The shuttle car transports the coal to a loading ramp and unloads it on a 30-inch belt which conveys and dumps the coal intO 8-ton capacity steel mine cars. Loading ramps are 200 feet apart.

The average advance of a 16-foot wide entry, room, and crosscut is 41 feet per shift for the group. Each unit produces 114 tons of raw coal per shift, yielding 113.7 tons of clean coal. This is 16.7 tons of raw coal or 16.6 tons of clean coal per shift for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | 1/3 |
| 1 Continuous-mining machine operator | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Shuttle-car operator | Do. |
| 2 Roof bolters | Do. |
| 1 Mechanic | 1/2 |
| 1 Beltman | Full-time |
| Total 8 men working | 6-5/6 shifts |

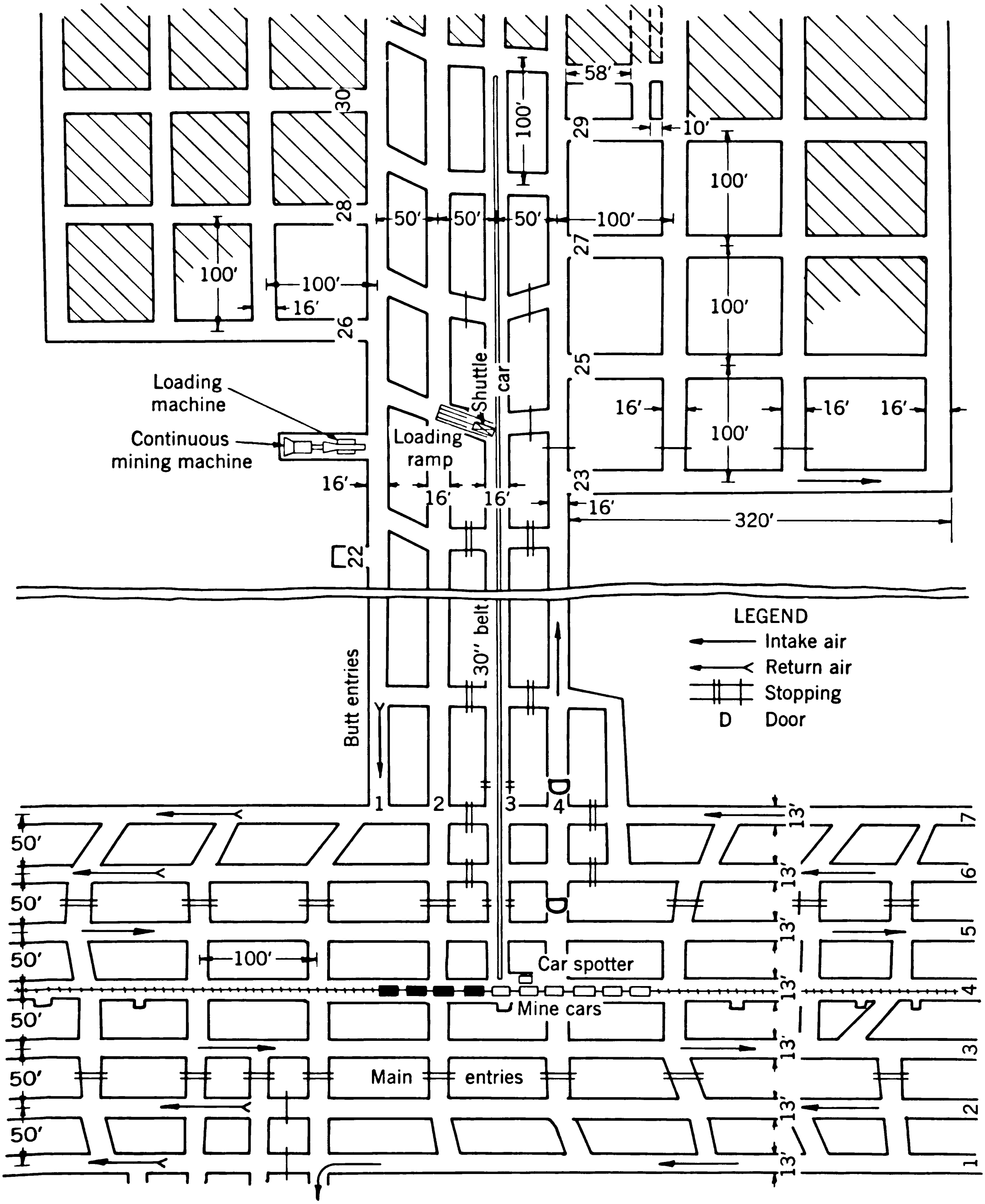

FIGURE 15. - Butt-Entry Development, Room-Mining and Pillar-Extraction Plan with a Continuous-Mining Machine Using a Loading Machine and Shuttle Car at Mine 6.

Face-haulage delays (29 minutes) were due to mechanical failures of the shuttle car. Production delays (136 minutes) resulted from mechanical failures and maintenance of continuous-mining machine, 90 minutes, and tramming, 46 minutes. Other delays (30 minutes) were for waiting on empties. Travel time required 64 minutes, and lunch took 30 minutes, leaving 386 minutes for face time. Total face delays were 195 minutes, allowing 191 minutes' productive time per shift.

## Mobile Loading to Shuttle-Car Haulage

Two sets of butt entries are turned 90 degrees on 500-foot centers from the mains and are driven 2,000 feet. Entries 14 feet wide are driven on 100-foot centers with crosscuts 14 feet wide turned on an angle 80 to 90 degrees on 100-foot centers. (See fig. 16.)

One mobile-loading unit is used to advance both sets of entries one set at a time. The unit consists of eight men, two cutting machines with two drills, two loading machines, two rotary roof-bolting machines, two shuttle cars, and two locomotives. One-half the equipment is assigned to each set of entries. If a major breakdown of any of the equipment occurs that impairs production in the set of entries being advanced, the crew moves to the other set and continues work. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine between shifts and on weekends.

The cycle of operations is: Set safety posts, roof bolt, drill and cut, blast, rock dust, and load coal.

Entries and crosscuts are roof bolted similarly to the bolting pattern described in butt-entry development with a continuous-mining unit. Entries and crosscuts are top cut and sheared on the right rib. Two blast holes, each 9 feet deep, are drilled 1 foot above the bottom. One hole is 1 foot from the left rib, and the other is 1 foot to the right of center. Each hole is charged with 5-1/2 sticks of permissible powder and is blasted one hole at a time.

The mined coal is loaded by a mobile-loading machine into a 6-1/2-ton capacity shuttle car which transports and unloads the coal into 8-ton capacity steel mine cars. The cars are moved and spotted at the loading ramp by the shuttle-car operator using a remote-controlled 8-ton locomotive. Loading ramps are moved every 200 feet of advance.

The average advance of each entry or entry and crosscut is 9 feet per shift or 45 feet per shift for the group. A unit produces 159 tons of raw coal per shift, yielding 158.6 tons of clean coal. This is 19.9 tons of raw coal or 19.8 tons of clean coal for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.................................. | 1/2 |
| 1 Loading-machine operator.......................... | Full-time |

| CLASSIFICATION: (Con.) | Assigned time per shift |
|---|---|
| 1 Loading-machine operator's helper and shotfirer... | Full-time |
| 1 Cutting-machine operator (also driller)........... | Do. |
| 1 Cutting-machine operator's helper (also driller).. | Do. |
| 2 Roof bolters...................................... | Do. |
| 1 Shuttle-car operator.............................. | Do. |
| 1 Mechanic.......................................... | 1/2 |
| Total............................ 9 men working | 8 shifts |

Face-haulage delays (15 minutes) consisted of mechanical failure of the shuttle car. Production delays (45 minutes) were for mobile-loading machine repairs, 30 minutes, and greasing, 15 minutes. Other delays (30 minutes) were for waiting on empties. Travel time required 55 minutes, and lunch took 30 minutes, leaving 395 minutes for face time. Total face delays were 95 minutes, allowing 300 minutes' productive time per shift.

### Track Loading to Mine-Car Haulage

Butt entries in sets of three on 75-foot centers are turned 90 degrees from the mains on 475-foot intervals and are driven 230 feet. As shown in figure 17, an additional entry on each side of the set is driven from the barrier pillar. The entries are 14 feet wide with crosscuts 14 feet wide at an angle of 80 to 90 degrees on 100-foot centers. The length of the panel is 2,000 feet.

A unit consists of 8-1/3 men, one track-mounted mobile loading machine, one track-mounted cutting machine equipped with a drill, one stoper, one 8-ton locomotive, and one compressor that serves two units. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine between shifts and on weekends.

The cycle of operations is: Set safety posts, lay track, roof bolt, drill and cut, blast, rock dust, and load coal.

Entries and crosscuts are roof bolted similarly to the bolting pattern previously described. Entries and crosscuts are top cut and sheared on the right rib. Three blast holes, each 9 feet deep, are drilled one near the left rib and about 8 inches above the bottom, one 2 feet to the right of center 8 inches above the bottom, and one 2 feet to the right of the left rib and 50 inches above the bottom. The two bottom holes are each charged with six sticks of permissible powder, and the top hole is charged with three sticks. They are blasted one hole at a time.

The mined coal is loaded by a mobile-loading machine into 8-ton capacity steel mine cars and is hauled to a nearby storage track by an 8-ton locomotive which returns with 10 empty cars to the working section.

The average advance of each entry or entry and crosscut is 7 feet per shift or 35 feet for the group. A unit produces 136 tons of raw coal per shift, yielding 135.7 tons of clean coal. This is 16.4 tons of raw coal or

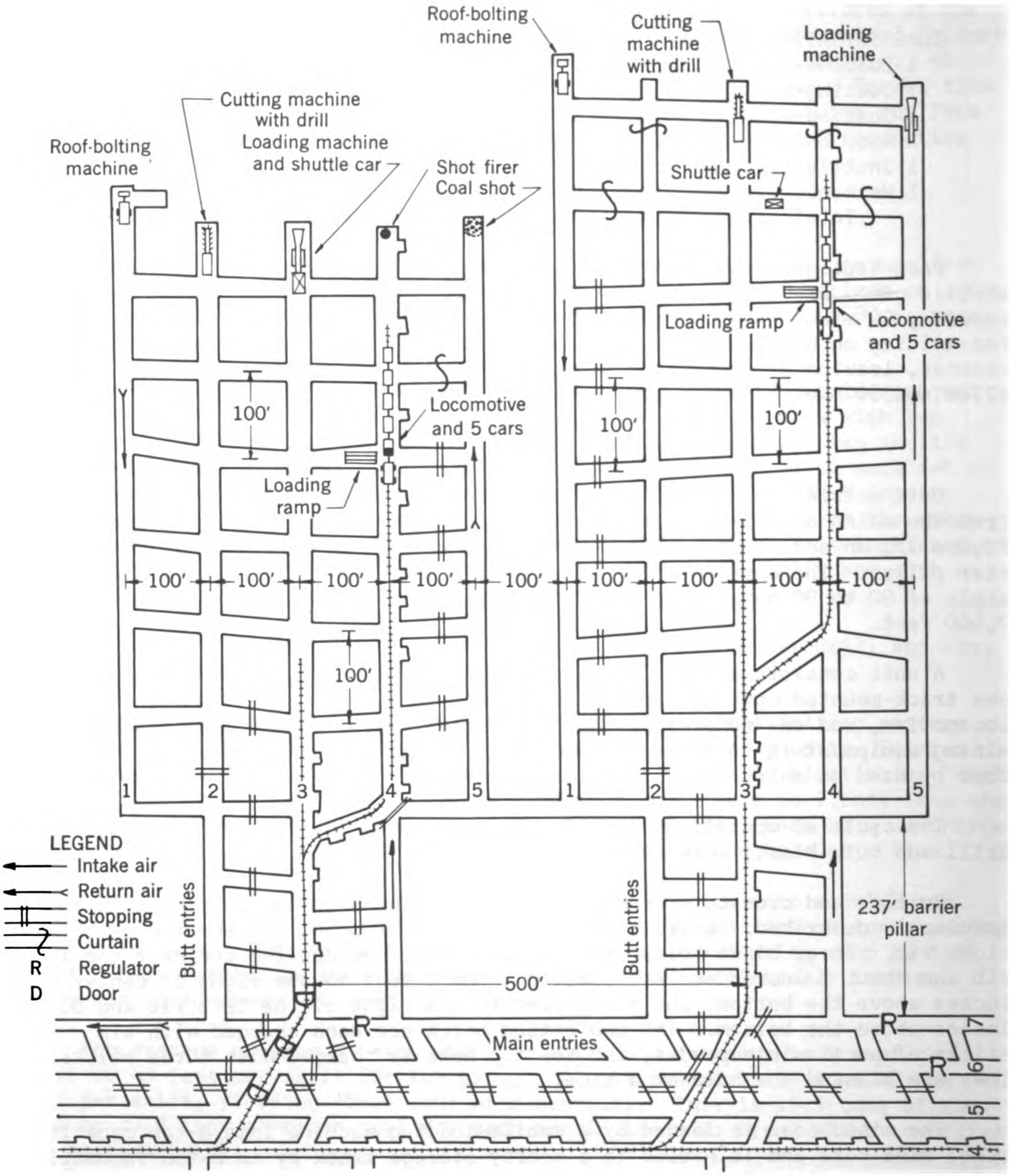

FIGURE 16. - Two-Butt-Entry-Development Plan by a Unit Crew Using Two Sets of Mobile-Loading Equipment and Two Shuttle Cars at Mine 6.

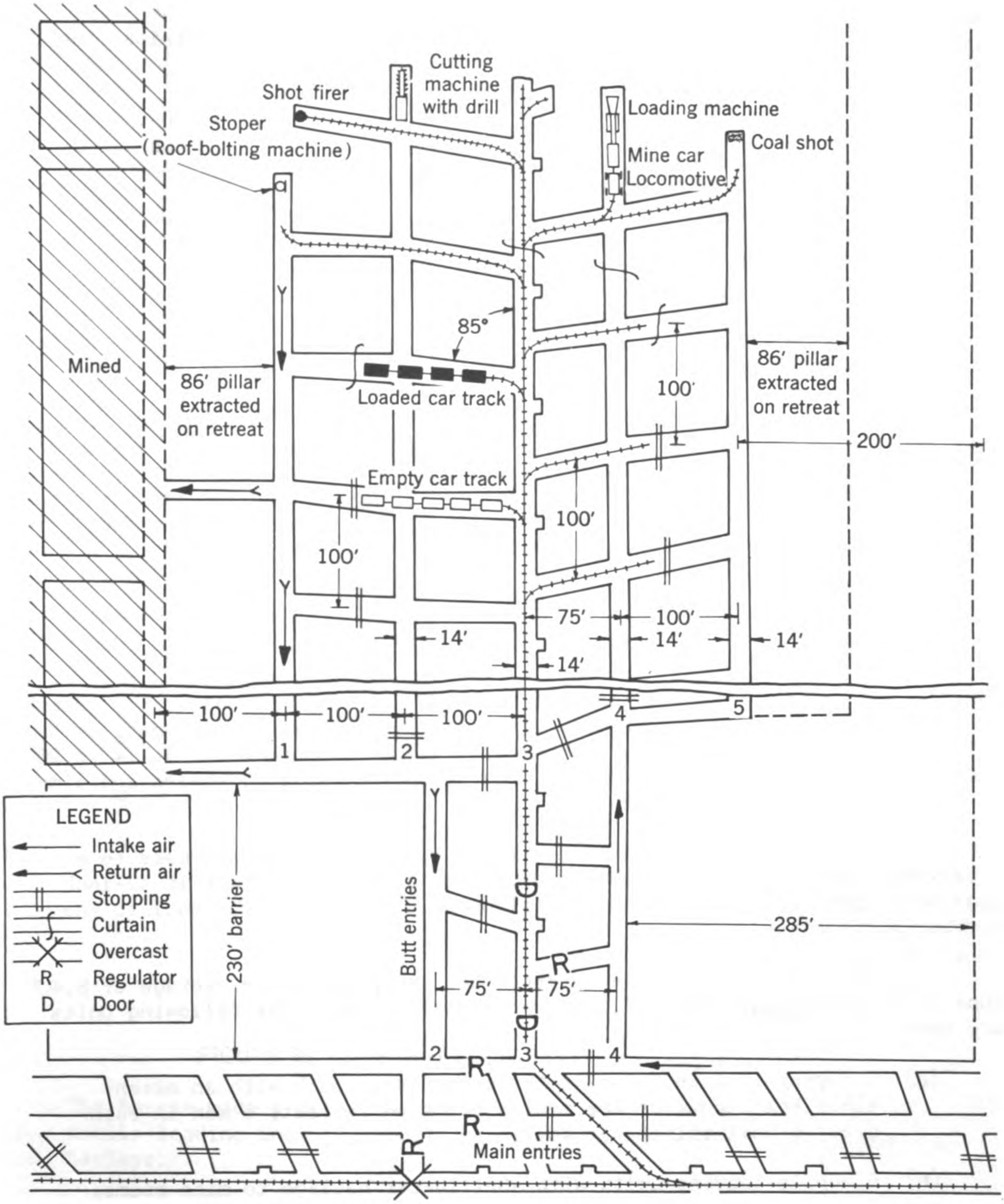

FIGURE 17. - Butt-Entry-Development Plan with a Mobile-Loading Machine and Track-Mounted Mining Equipment Using Mine Cars at Mine 6.

16.3 tons of clean coal for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | | Assigned time per shift |
|---|---|---|
| 1 Section foreman | | 1/3 |
| 1 Loading-machine operator | | Full-time |
| 1 Loading-machine operator's helper | | Do. |
| 1 Cutting-machine operator | | Do. |
| 1 Cutting-machine operator's helper | | Do. |
| 1 Shotfirer (also rock dusts) | | Do. |
| 2 Roof bolters (also track layers) | | Do. |
| 1 Motorman | | Do. |
| Total | 9 men working | 8-1/3 shifts |

Face-haulage delays (85 minutes) were for waiting on loading and tramming empties. Production delays (95 minutes) concerned preparation of the face, 72 minutes, and maneuvering the loading machine, 23 minutes. Other delays were 41 minutes for roof bolting. Travel time required 102 minutes and lunch took 30 minutes, leaving 348 minutes for face time. Total delays at the face were 221 minutes, allowing 127 minutes' productive time per shift.

## Mine 7

This mine is operated in the Pittsburgh No. 8 bed which averages 62 inches thick in this area. The bed is flat-lying with some local dips. A pyritic and a shale parting, each 1 inch thick, occur 20 and 41 inches respectively, above the bottom of the bed. (See fig. 18.) The bed is underlain by fire clay and is overlain by 12 inches of draw slate above which is 14 to 20 inches of roof coal. The overburden consists principally of shales and limestones and averages 200 feet thick.

Mine cars are hauled by a 15-ton locomotive in trips of 35 cars to a rotary dump at the bottom of the slope. The main haulage track is 42-inch gage using 60-pound rail. A 48-inch slope belt transports the coal to the surface preparation plant.

The mine is operated three shifts a day and produces an average of 8,400 tons of raw coal that yields 7,100 tons of clean coal. The following units are used:

(a) 2 ripper-type continuous-mining machines, each with an extensible belt conveyor for mining rooms on retreat; 6 men in each crew; 6 unit shifts per day;

(b) 6 mobile-loading units with shuttle-car haulage to mine rooms; 9 men in each crew; 18 unit shifts per day;

(c) 6 mobile-loading units with shuttle-car haulage to develop entries; 9 men in each crew; 18 unit shifts per day.

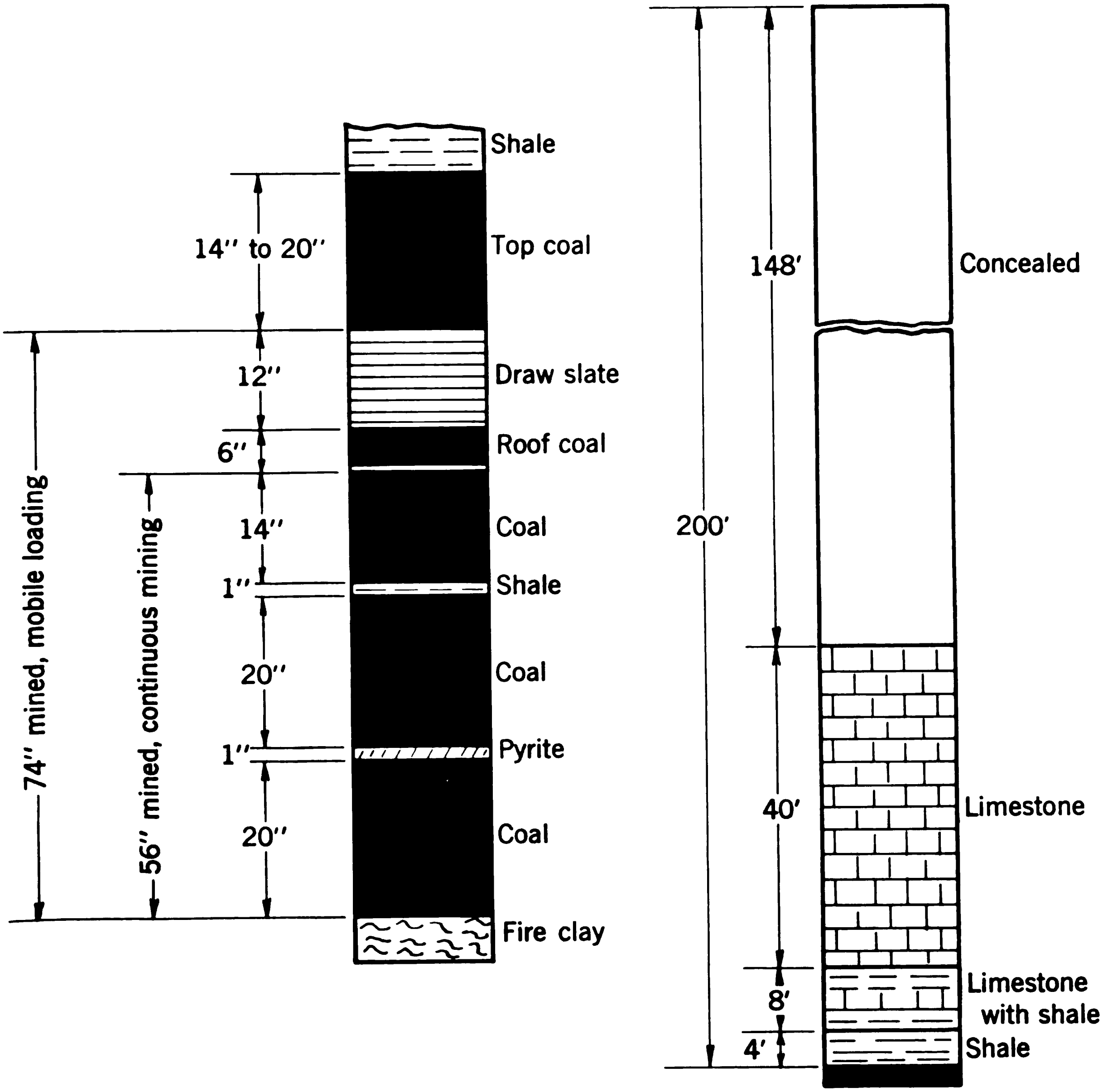

FIGURE 18. - Section of Coalbed and Overburden at Mine 7.

The Bureau made a detailed study of the continuous-mining units (a) and of a mobile-loading unit (b) working in rooms to compare the two systems of face haulage.

### Extensible Belt Haulage

All development work preparing a panel for the retreat mining of the rooms is done with mobile-loading equipment and shuttle cars. Butt entries 12 feet wide are driven in sets of five on 40-foot centers with crosscuts 12 feet wide on 32-foot centers. Rooms are necked 16 feet wide on 32-foot centers and are driven 27 feet deep as the two outside entries of the group advance. (See fig. 19.) Only entries and room necks are roof bolted with 5/8-inch expansion shell-type bolts 72 inches long. They are set 3 feet apart in lines parallel with the centerlines of the entries and room necks. One line is set 1 foot to the left, and the other is set 1 foot to the right of the entry and room neck centerline. The bolts in one line are staggered with those in the other line. All bolts are set against 6- by 6- by 1/4-inch steel-bearing plates on 2- by 6- by 15-inch wood headers. The draw slate above the coal is mined with the coal, but the roof bolts hold the top coal in place. Roof bolts are recovered from completed entries and room necks before the places are abandoned.

In developing panels for rooms that are to be mined on retreat by continuous-mining units using extensible belts, the middle entry is equipped with a 30-inch belt. This belt conveys the mined coal to 6-ton capacity steel mine cars for transportation to the rotary dump at the slope. The butt entries are driven 1,500 feet before room mining is begun.

To start retreating in a panel, the two inby rooms on one side are mined simultaneously. Rooms are driven 560 feet long and 16 feet wide on 32-foot centers with crosscuts 16 feet wide on 45-foot centers. On completion of these rooms, the two inby rooms on the opposite entry are mined similarly. When the two inby rooms on each side of the panel are completely mined, one mining unit works on each room entry, and each mines one room at a time until the panel is completed.

A continuous-mining unit consists of six men, one continuous-mining machine, one supply truck, and one extensible belt together with one 30-inch mother belt and one car hoist for each two units. Power to operate the machinery is furnished at 275 volts direct current. Rock dusting is done by hand in rooms on shift and by machine in entries as required.

In room mining with the continuous-mining units, about 6 inches of coal are left to keep the draw slate from falling and from contaminating the mined coal. Rooms are timbered with 4-inch steel H-beams 12 and 14 feet long set 3 feet apart. The beams are raised and held to the roof by hydraulic jacks on the continuous-mining machine until a wood post is placed under each end. All roof supports in rooms are recovered. As mining progresses, the adjacent inby room is maintained as a travelway, and timbers in the second inby room are recovered through crosscuts as needed for the room being mined.

The average advance of each mining machine is 55 feet of room or crosscut per shift. Each unit produces 200 tons of raw coal per shift or 33 tons per man in the unit crew. This coal is not sent through the cleaning plant. The unit crew consists of:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman.................................... | 1/2 |
| 1 Continuous-mining machine operator................ | Full-time |
| 2 Continuous-mining machine operator's helpers...... | Do. |
| 1 Supply man......................................... | Do. |

| CLASSIFICATION: (Con.) | | Assigned time per shift |
|---|---|---|
| 1 Loading-point man | | 1/2 |
| 1 Mechanic[1] | | Full-time |
| Total | 7 men working | 6 shifts |

[1] Not considered part of crew by company.

Face-haulage delays (13 minutes) were for extending the extensible belt. Production delays (30 minutes) were for waiting on coal from the continuous-mining machine (mechanical). Other delays (90 minutes) were due to timbering, 30 minutes, and waiting on empties, 60 minutes. Travel time required 75 minutes, and lunch took 30 minutes, leaving 375 minutes available for face time. Total delays at the face were 133 minutes, allowing 242 minutes' productive work time per shift.

## Shuttle-Car Haulage

An entirely different plan is developed for room mining using mobile-loading equipment. Five butt entries 12 feet wide are driven on 40-foot centers with crosscuts 12 feet wide spaced as shown in figure 20. Rooms are necked 15 feet wide on 25-foot centers as the entries are advanced. The same pattern of roof bolting as described previously is used in the entries and room necks.

Entries 2 and 4 are equipped with 42-inch gage track using 40-pound rails. Circle loading stations are established every 200 feet as the entries advance and are removed on retreat as room mining is completed. The entries are driven 2,330 feet for each panel.

Rooms are driven 242 feet deep with crosscuts 15 feet wide on 80-foot centers and are staggered. Rooms are mined in groups of seven alternately from one side to the other. A pillar 35 feet wide is left unmined between each group of rooms.

A unit consists of nine men, one shortwall cutting machine with truck, two post-mounted drills, three blowdown valves, one firing shell (compressed air), one loading machine, one roof-bolting machine, and two shuttle cars (one being a reserve). Power to operate the machinery is furnished at 275 volts direct current. Rock dusting is done by hand on shift.

The draw slate is taken down, and the top coal is bolted. The roof bolts are recovered as the rooms are completed.

Eight blast holes, each 2-1/4 inches in diameter and 9 feet long, are drilled in the face of a room. Two holes are drilled 1 foot above the bottom, one on each rib; one hole in the center about 30 inches above the bottom; two holes, one on each rib below the draw slate; and three holes approximately on the centerline of the draw slate, one near each rib, and one midway between ribs. The coal is undercut and blasted one hole at a time with a compressed air shell (8,000 to 10,000 p.s.i.).

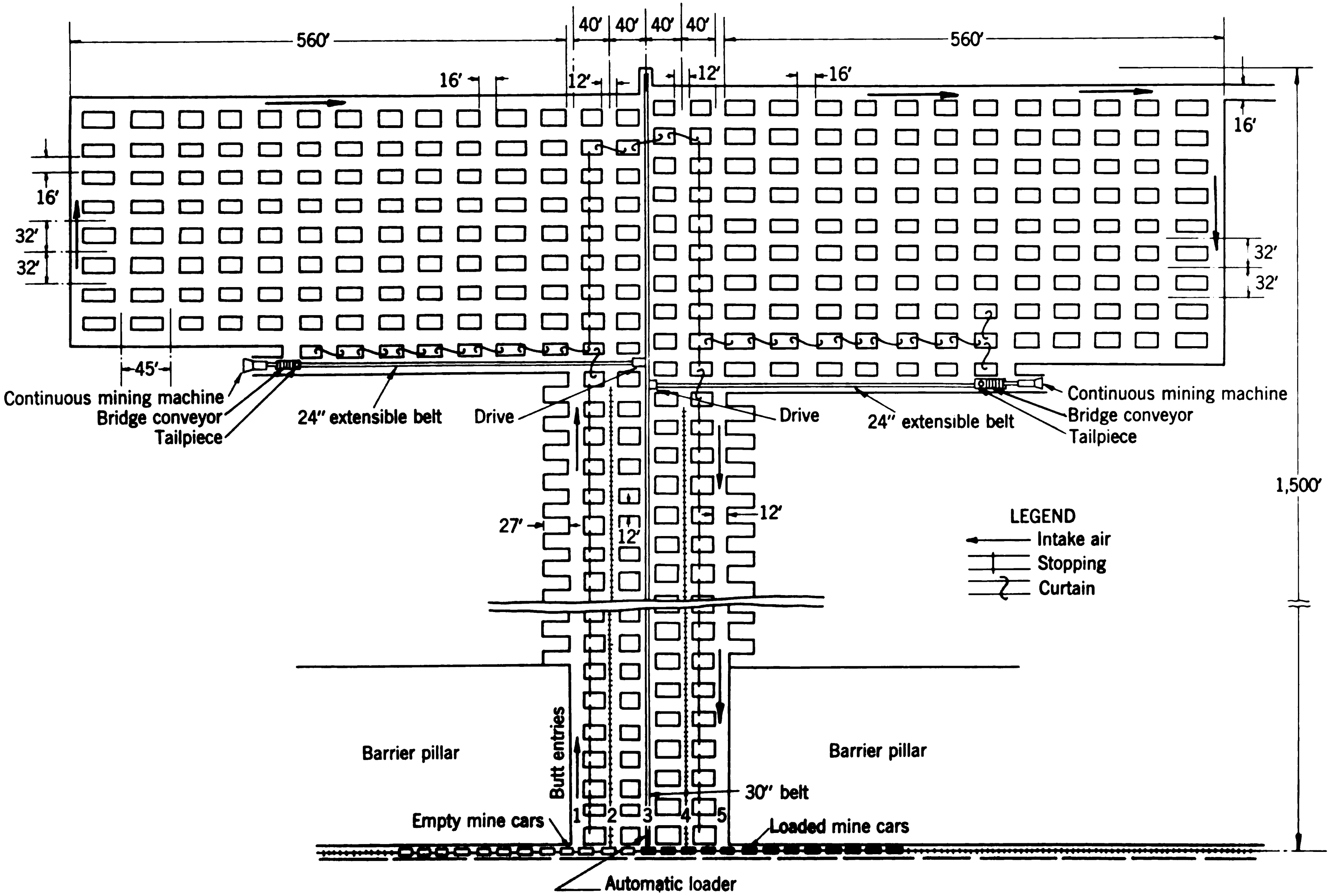

FIGURE 19. - Room-Mining Plan with Two Continuous-Mining Machines Using Two Extensible Belts at Mine 7.

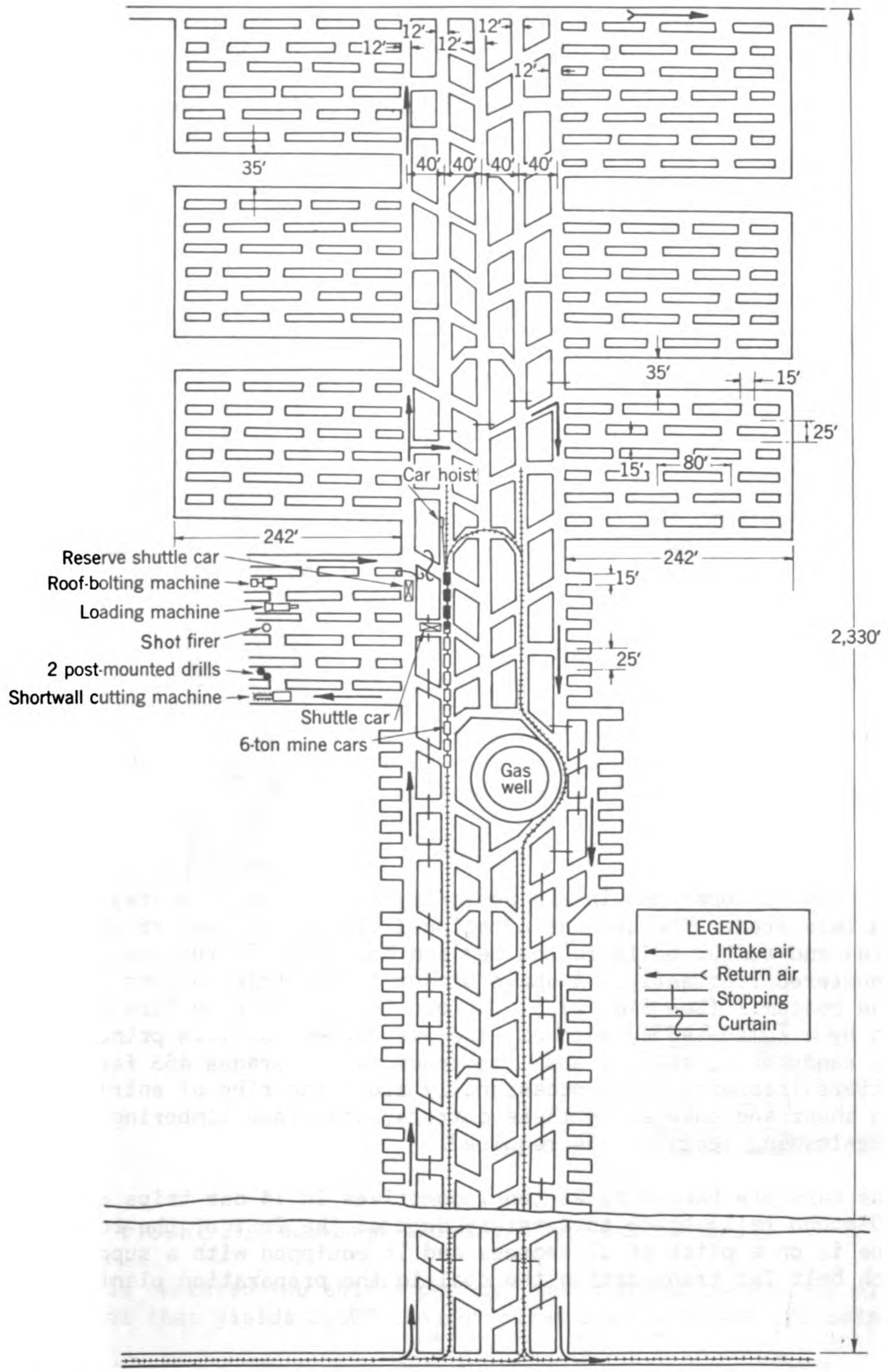

FIGURE 20. - Room-Mining Plan with a Mobile-Loading Unit Using Two Shuttle Cars at Mine 7.

The mined coal is transferred from the shuttle car into 6-ton capacity steel mine cars for haulage to the rotary dump at the slope bottom.

The average advance of each room or crosscut is 7.9 feet per shift or 55.3 feet for seven rooms. A unit produces 200 tons of raw coal per shift, yielding 164 tons of clean coal (based on a reject of 18 percent in the cleaning plant. This is 22.2 tons of raw coal or 18.2 tons of clean coal for each man in the unit crew, which comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman[1] | 1/2 |
| 1 Loading-machine operator | Full-time |
| 1 Loading-machine operator's helper | Do. |
| 1 Cutting-machine operator | Do. |
| 1 Cutting-machine operator's helper | Do. |
| 2 Driller and shotfirer | Do. |
| 1 Shuttle-car operator | Do. |
| 1 Roof bolter | Do. |
| 1 Mechanic[1] | 1/2 |
| Total 10 men working | 9 shifts |

[1] Not considered part of crew by company.

Face-haulage delays (20 minutes) were due to the shuttle car (mechanical). Production delays (23 minutes) consisted of mechanical failure of the loading machine. Other delays (71 minutes) were for timbering, 20 minutes, and waiting on empties, 51 minutes. Travel time required 60 minutes, and lunch time was staggered, leaving 420 minutes for face time. Total face delays were 114 minutes, allowing 306 minutes' productive time per shift.

## Mine 8

This mine is operated in the Sewickley coalbed which averages 65 inches thick in this area. The bed has a regional dip to the west of about 2 percent. Clay veins and sulfur balls in the bed and horseback intrusions in the roof are encountered frequently. A shale binder 1 inch thick occurs 13 inches above the bottom. (See fig. 21.) The bed is underlain by fire clay and is overlain by a laminated sandstone. The overburden consists principally of one coalbed, sandstones, shales, and limestones, and averages 463 feet thick. Roof cutters (rippers) occur occasionally along the ribs of entries. The roof tends to shear and cave along these cutters, and close timbering (roof bolting in mobile-loading sections) is required.

Mine cars are hauled by 23-ton locomotives in 14 car trips over 42-inch gage (80-pound rail) track to a rotary dump at the foot of the rock slope. The slope is on a pitch of 17 degrees and is equipped with a supply track and a 42-inch belt for transporting the coal to the preparation plant.

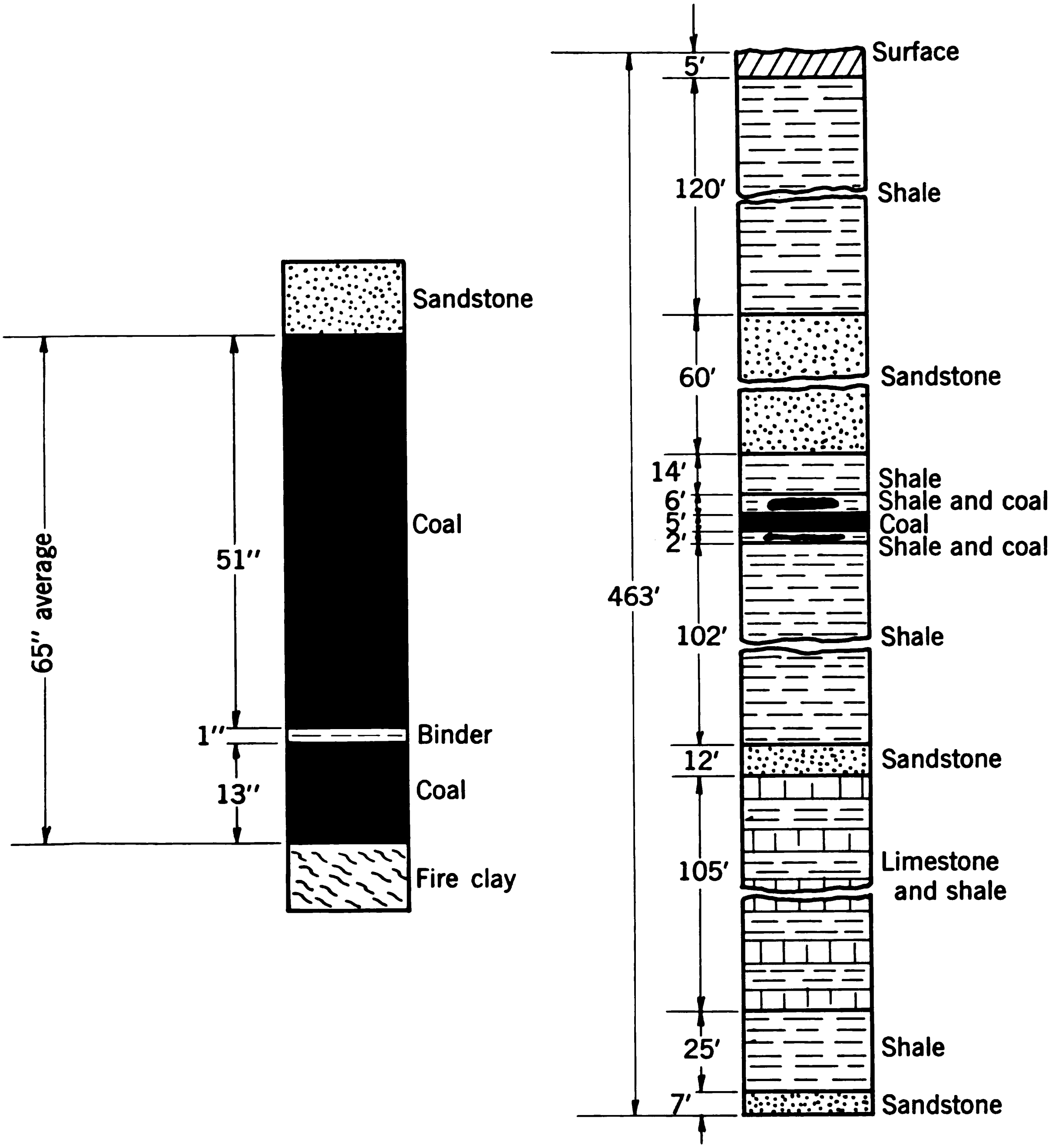

FIGURE 21. - Section of Coalbed and Overburden at Mine 8.

The mine is operated two shifts per day and produces an average of 3,060 tons of raw coal that yields 2,600 tons of clean coal with the following units:

(a) 2 ripper-type continuous-mining units, each with 1 loading machine and 1 shuttle car to develop entries and crosscuts; 7 men in each unit; 4 unit shifts per day;

(b) 4 mobile-loading units, each with 2 shuttle cars to develop entries and crosscuts; 10 men in each unit; 8 unit shifts per day.

A detailed study was made of the continuous-mining units and of the mobile-loading units to compare the two face-haulage systems.

Entries 16 to 18 feet wide on 80-foot centers are driven in sets of five with the continuous-mining machine. Crosscuts also are driven 16 to 18 feet wide on 80-foot centers. The resultant blocks are 63 feet square. (See fig. 22.) Entries are developed using the sequence of cuts one to nine as shown; after cut nine the continuous-mining machine is returned to cut one, and the cycle is repeated.

A continuous-mining unit consists of seven men, one continuous-mining machine, two loading machines (one spare), one shuttle car, one high pressure pump, one rock-dusting machine, and an 8-ton locomotive. Power to operate the equipment is furnished at 250 volts direct current. Rock dusting is done on shift and after the second shift.

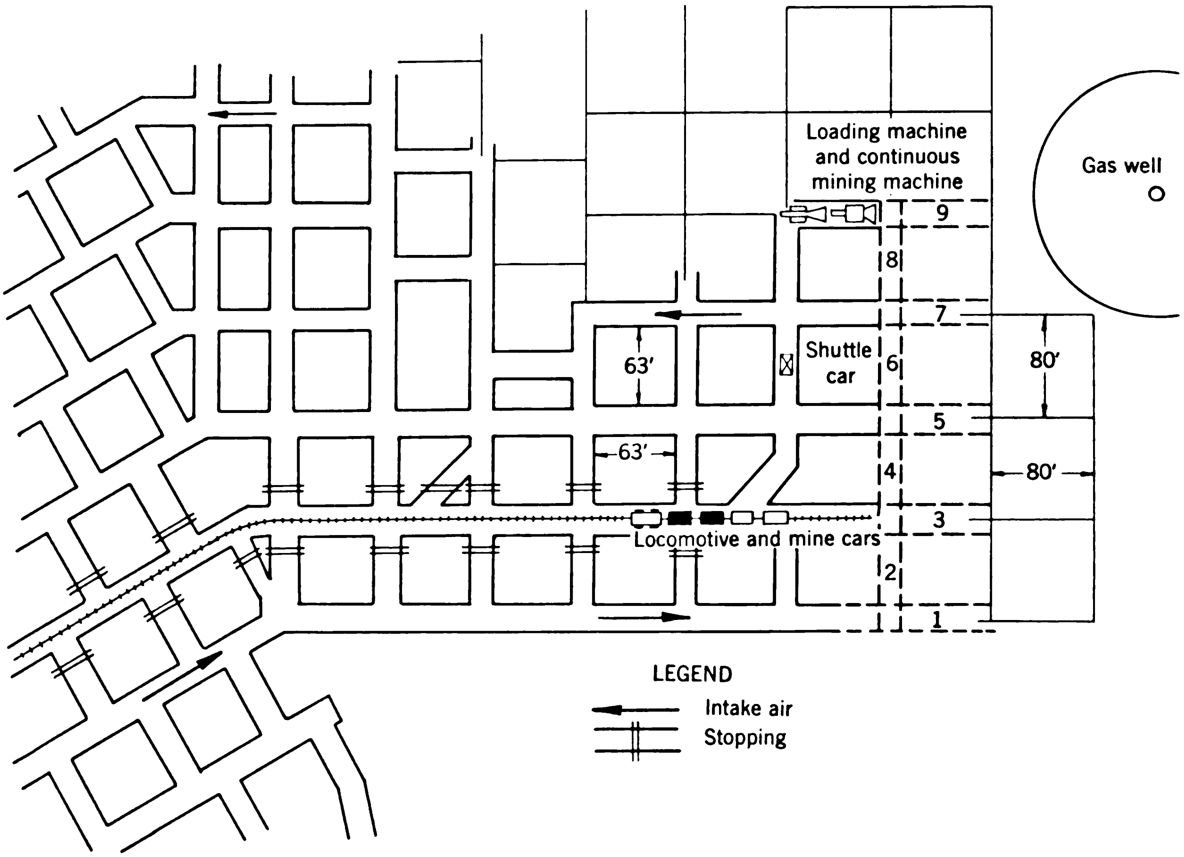

FIGURE 22. - Entry-Development Plan with a Continuous-Mining Machine Using a Loading Machine and Shuttle Car at Mine 8.

Entries are timbered with wood crossbars 5 inches by 7 inches by 14 feet long set on wood posts and on 3-foot centers.

The continuous-mining machine discharges the coal on the floor, and the mobile-loading machine reloads the coal into a 6-ton capacity shuttle car. Use of the loading machine permits the continuous-mining machine to operate even though the shuttle car is delayed and provides better cleanup. The shuttle car loads directly into 7-1/2-ton capacity steel mine cars which are spotted and moved at the loading ramp by an 8-ton locomotive. Usually a new loading station is established every 250 feet of advance.

The average advance of each entry or entry and crosscut is 13.6 feet per shift or 68 feet per shift for the 5 entries and the crosscuts. A unit produces 255 tons of raw coal per shift, yielding 217 tons of clean coal. This is 36.4 tons of raw coal or 31 tons of clean coal per shift for each man in the unit crew, which consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Continuous-mining machine operator | Do. |
| 1 Loading-machine operator | Do. |
| 2 Timbermen | Do. |
| 1 Shuttle-car operator (also acts as mechanic) | Do. |
| 1 Motorman | Do. |
| Total ... 7 men working | 7 shifts |

Face-haulage delays (30 minutes) were due to the shuttle car (mechanical). Production delays (60 minutes) consisted of waiting on continuous-mining machine (mechanical). Other delays (90 minutes) were for timbering, 50 minutes; and waiting on empties, 40 minutes. Travel time required 20 minutes, and lunch time was staggered, leaving 460 minutes available for face time. Total face delays were 180 minutes, allowing 280 minutes' productive time per shift.

The mobile-loading units are used also in development. Entries 14 feet wide and on 80-foot centers are driven in sets of four, five, and eight with crosscuts (usually staggered) 14 feet wide on 80-foot centers, leaving blocks 66 feet square. (See fig. 23.) On developing an eight-entry system, four entries on one side are advanced two or three crosscuts, and then the other four entries are advanced four to six crosscuts (two or three crosscuts) ahead of the first group.

An entry unit consists of ten men, two loading machines (one spare), one cutting machine with hydraulic drill, two shuttle cars, one stoper, one rock-dusting machine, and a 6-ton locomotive. Power to operate the equipment is furnished at 250 volts direct current. Rock dusting is done on shift and after the second shift.

The cycle of operations is: Roof bolt, cut, drill, blast, and load coal.

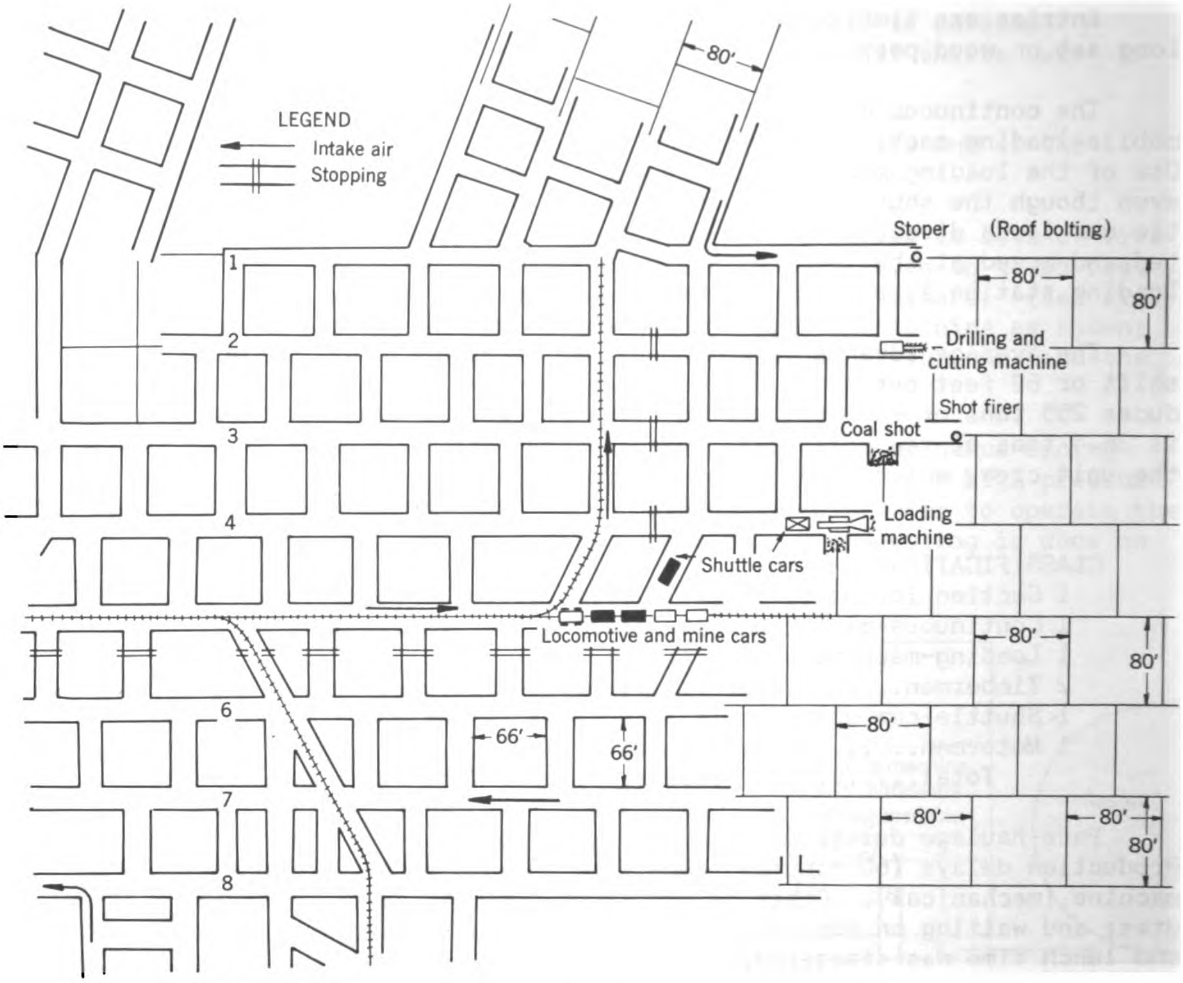

FIGURE 23. - Entry-Development Plan with a Mobile-Loading Unit Using Two Shuttle Cars at Mine 8.

Entries are bolted with 1-inch wedge type bolts in sets of three across the entry, spaced 3, 7, and 11 feet from either rib. Bolts are 60 inches long set against 6- by 6- by 3/8-inch steel plates which are set against a board 2 inches by 6 inches by 12 feet long. These boards are spaced 3 feet apart. Compressed air for the stoper is delivered through a 3-inch pipeline from a compressor on the surface.

Entries are bottom cut and sheared 2 feet to the right of center and from 2 feet below the roof line to the bottom. Three blast holes, each 9 feet deep, are drilled 2 feet below the roof line; one in the center and one each, 6 feet to the left and right of center. Each hole is charged with four to five sticks of permissible powder and blasted one hole at a time.

The mined coal is loaded by the mobile-loading machine into two shuttle cars which transport and unload the coal into 7-1/2-ton steel mine cars, which are spotted and moved at the loading ramp with a 6-ton locomotive. Loading ramps are moved every 250 feet of advance. The loaded cars are transported in 14 car trips by a 23-ton locomotive to the rotary dump at the foot of the slope.

The average advance of each entry or entry and crosscut in a set of five entries is 15.6 feet per shift or 78 feet per shift for the group. A unit produces 255 tons of raw coal per shift, yielding 217 tons of clean coal. This is 25.5 tons of raw coal or 21.7 tons of clean coal per shift for each man in the unit crew, which consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Cutting-machine operator-driller | Do. |
| 1 Cutting-machine operator driller's helper | Do. |
| 1 Shotfirer | Do. |
| 2 Roof bolters | Do. |
| 2 Shuttle-car operators | Do. |
| 1 Motorman | Do. |
| Total 10 men working | 10 shifts |

Face-haulage delays (30 minutes) were due to the shuttle car (mechanical). Production delays (60 minutes) were caused by mechanical failure of mobile-loading machine. Other delays (90 minutes) resulted from timbering, 60 minutes; and waiting on empties, 30 minutes. Travel time required 50 minutes, and lunch time was staggered, leaving 430 minutes for face time. Total face delays were 180 minutes, leaving 250 minutes' productive time per shift.

## Mine 9

This mine is operated in the Pittsburgh No. 8 bed which averages 62 inches thick in the area. The bed is flat-lying with local dips and has some horseback intrusions in the bottom. A pyritic parting one-half inch thick, a shale band 2-1/2 inches thick, and bony coal 1 inch thick occur 15, 32-1/2, and 61 inches, respectively, above the bottom of the bed. (See fig. 24.) The bed is underlain by 6 inches or more of shale and overlain by 12 inches of draw slate above which is 24 inches of roof coal. The overburden consists principally of shales and limestones and ranges from 80 to 200 feet in thickness.

The loaded mine cars are transported in 28 car trips by a 27-ton locomotive to a rotary dump at the bottom of the slope. The main haulage track is 42-inch gage with 60-pound rail. The slope on a 16-degree pitch is equipped with a 60-inch belt conveyor for transporting the coal to a scalping plant on the surface and, also, a track for transporting supplies in mine cars.

The mine is operated three shifts per day and produces an average of 10,154 tons of raw coal that yields 6,600 tons of clean coal with the following units:

(a) 2 track-mounted units to develop entries; 10 men in each crew; 5 unit shifts per day;

(b) 4 track-mounted combination units to develop butt entries and mine rooms; 11 men in each crew; 10 unit shifts per day;

(c) 3 track-mounted wide units to mine rooms; 12 men in each crew; 6 unit shifts per day;

(d) 2 track-mounted units to mine room necks; 6 men in each crew; 2 unit shifts per day.

Detailed studies were made of the track-mounted units working in entries, butt entries, and rooms, and of the wide units in rooms.

### Entry Development With Track-Mounted Units

Six entries 12 feet wide on 27-foot centers are driven in sets of three with a 40-foot center between each set. Crosscuts are driven 8 feet wide on 75-foot centers, and chutes are driven 12 feet wide on varying centers as shown on the mine projection. (See fig. 25.)

A track-mounted entry unit consists of 10 men, one loading machine, one cutting machine, one track-mounted drill, three blowdown valves, a 3-inch compressed air shell, one roof-bolting machine, one 6-ton locomotive, and a push truck. Power to operate the equipment is furnished at 250 volts direct current.

The cycle of operations is: Set safety posts and lay track, roof bolt, cut, drill, blast, and load coal.

Entries are roof bolted with 5/8-inch expansion shell-type bolts 84 inches long, set 1 foot to the left and 1 foot to the right of the center line of the entry on 3-foot centers, and are staggered. The bolts are set against 6- by 6- by 1/4-inch steel plates. The draw slate above the coal is mined with the coal, and the bolts are set against the top coal. Roof bolts are recovered. Forty-pound steel rails for additional support at crossovers or for additional support in weak roof areas are set where required. The rails are 14 feet long set against the roof in hitches on each rib on 3-foot centers between the bolts.

All entries except the main-line-track entry are bottom cut and sheared on the right rib. This entry is bottom cut and sheared on both ribs. Six blast holes, each 9 feet deep, three in the middle of the draw slate (one 18 inches from each rib and one in the center); two 1 foot below the draw slate (spaced 18 inches and 3 feet from the left rib); and one immediately above the 2-1/2-inch band and 6 feet from the left rib are drilled in all entries

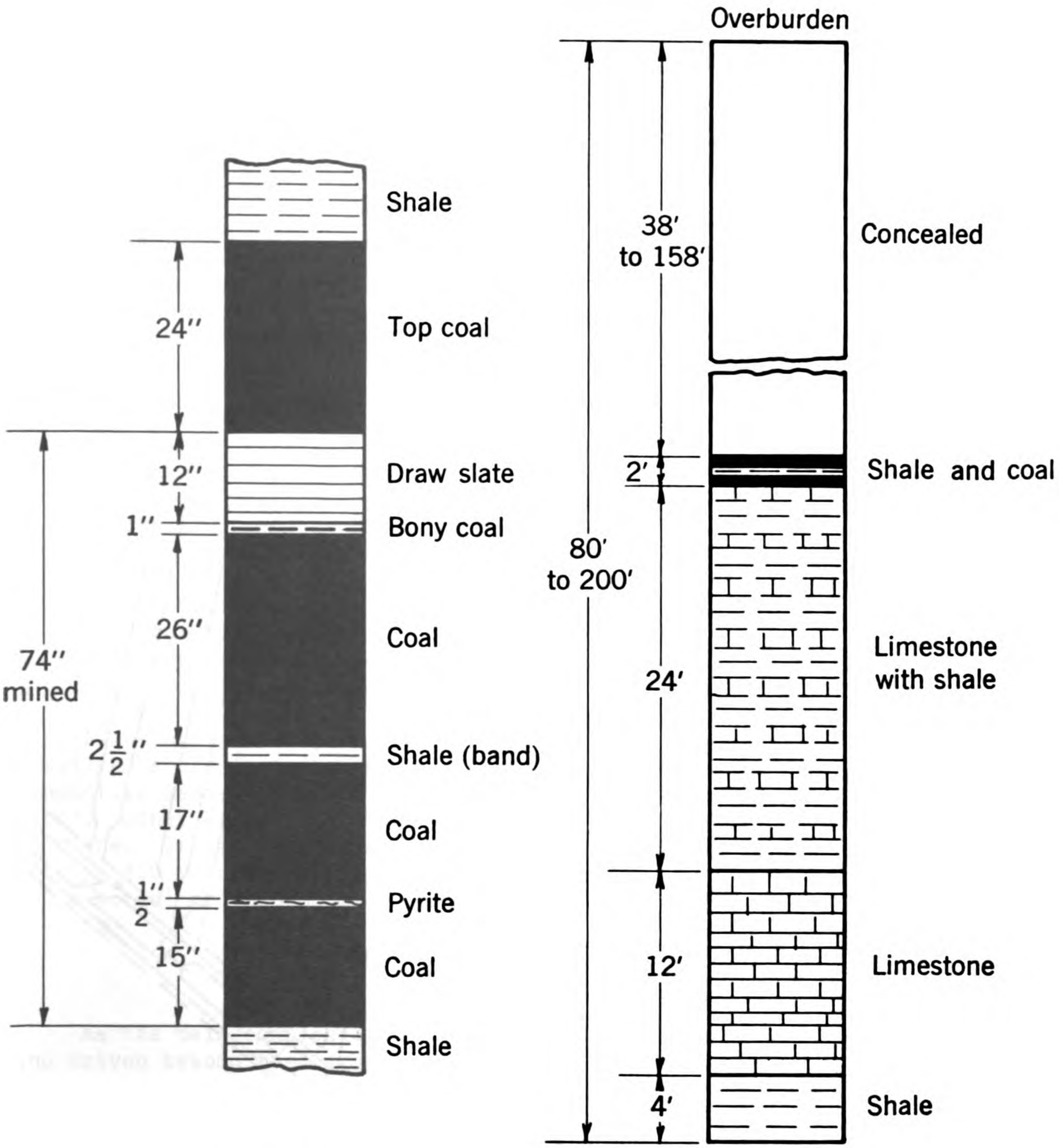

FIGURE 24. - Section of Coalbed and Overburden at Mine 9.

except the main track entry. In the track entry, two holes are drilled in the center of the place; one is drilled below the draw slate, and one is drilled above the 2-1/2-inch band. The holes are blasted one at a time with a 3-inch diameter compressed air shell (8,000 to 10,000 p.s.i.). Rock dusting is done by hand or by placing a bag of rock dust over the end of the shell and releasing the pressure.

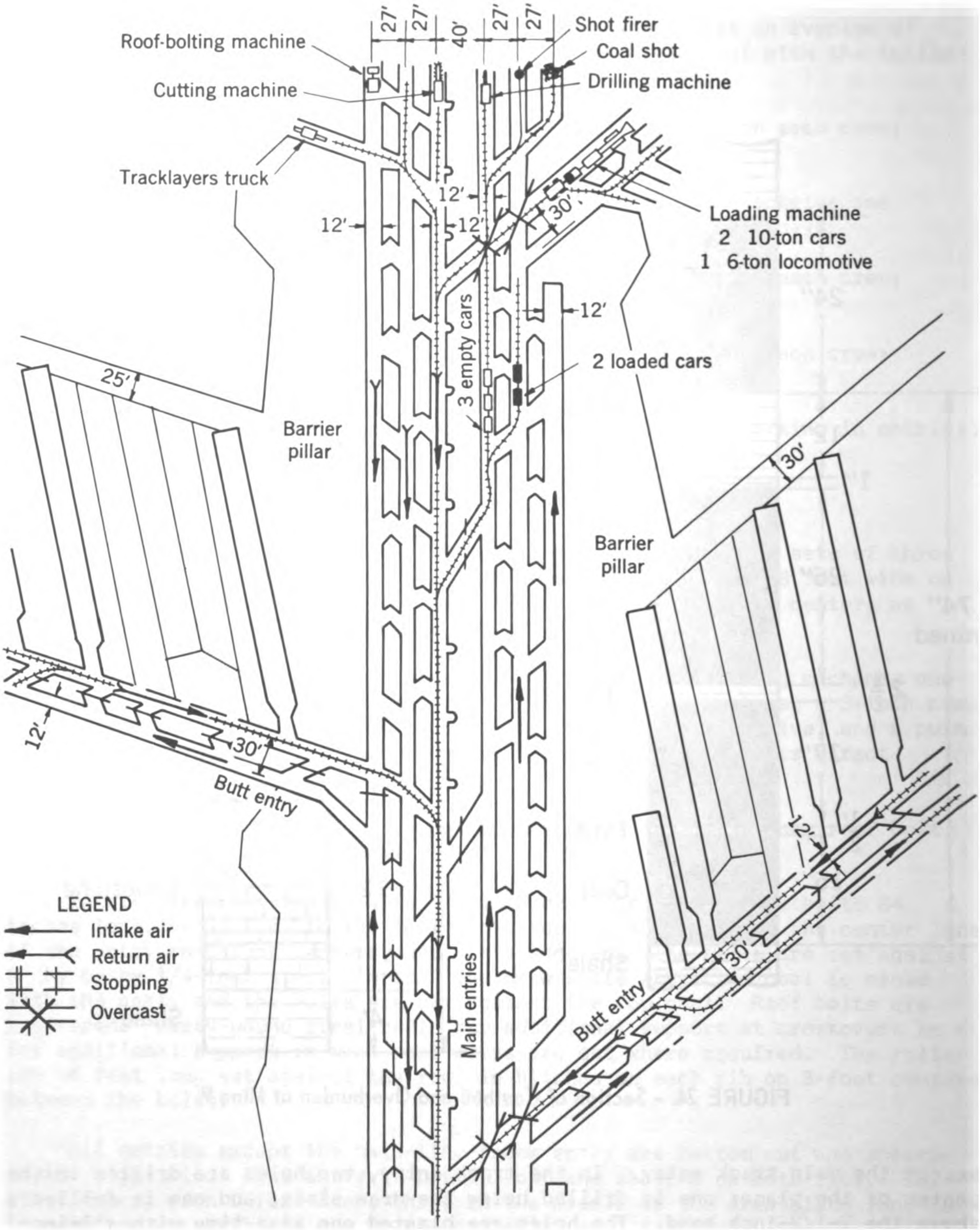

**FIGURE 25. - Entry-Development Plan with Track-Mounted Equipment Using Mine Cars at Mine 9.**

The mined coal is loaded into 10-ton steel mine cars by a track-mounted loading machine which is operated by two men; one at the loading head and one at the elevating conveyor. The cars are loaded 1 at a time and are trammed to a nearby storage track with a 6-ton locomotive. When seven cars have been loaded, they are trammed to a gathering station by an 8-ton (intermediate) locomotive which then returns with seven empty cars to the working section.

The average advance of each entry or crosscut is 15 feet per shift or about 90 feet total. A unit produces 323 tons of raw coal per shift, yielding 210 tons of clean coal based on a reject of 35 percent in the cleaning plant. This is 32.3 tons of raw coal or 21.0 tons of clean coal per shift for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Motorman | Do. |
| 2 Cutting machine men | Do. |
| 1 Driller | Do. |
| 1 Shotfirer | Do. |
| 1 Roof bolter | Do. |
| 1 Trackman | Do. |
| Total..........10 men working | 10 shifts |

Face-haulage delays (20 minutes) of track-mounted equipment consisted of derailments and tramming loaded and empty cars to and from the storage track. Production delays (20 minutes) resulted from waiting on coal (face preparation). Other delays (50 minutes) were due to waiting on empties from the mainline. Travel time required 60 minutes, and lunch time was staggered, leaving 420 minutes for face time. Total face delays were 90 minutes, leaving 330 minutes' productive time per shift.

### Butt Entries and Room Development With Track-Mounted Combination Units

As the main entries are developed, butt entries are turned where projected and driven beyond the first panel of rooms by the entry-development unit. A track-mounted combination entry-and-room unit then continues with the mining. Two butt entries 12 feet wide on 30-foot centers are driven to a depth of 2,600 feet. Crosscuts are driven 8 feet wide from both sides, and slant chutes are driven from the left side 12 feet wide as shown in figure 26. Rooms 22 feet wide are turned at 60 degrees on 35-foot centers (30-foot parallel centers) and are driven 280 feet off the right entry and 350 feet off the left entry. While mining a group of rooms (two, fig. 26), the two entries are advanced at the same time; also, the rooms in another group (three, fig. 26) are necked to allow the trackmen to install the switches without any interruption to production. The rooms in groups 4, 5, 6, 7, and 8 will be mined similarly as the entries are advanced. Rooms in groups 9, 10, 11, 12, 13, and 14 will be mined on retreat by a wide unit.

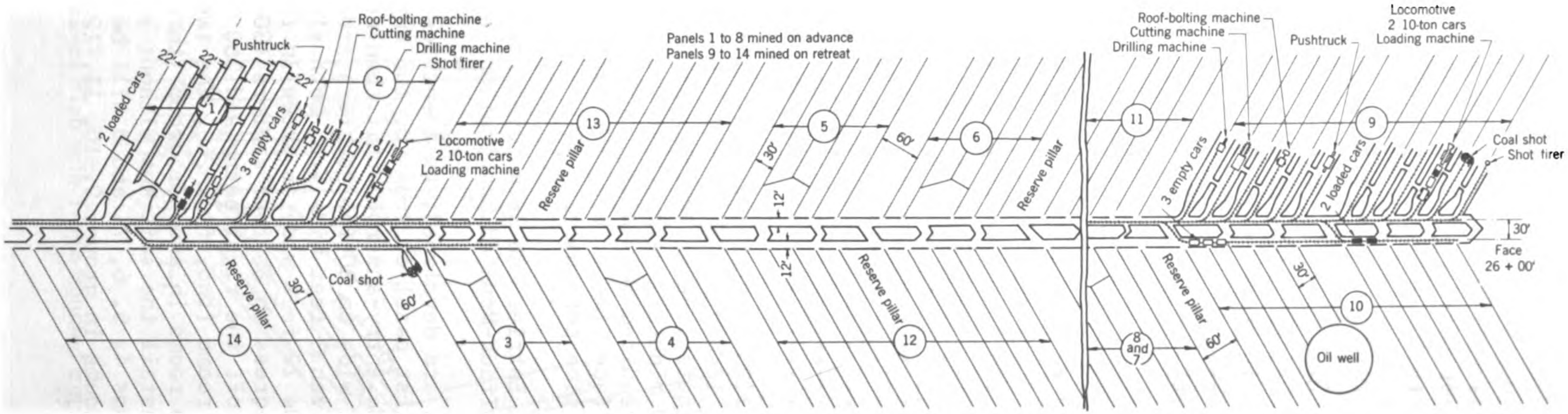

FIGURE 26. - Mining Plan to Develop Butt Entries and Rooms on Advance, Wide Rooms on Retreat with Track-Mounted Equipment Using Mine Cars at Mine 9.

A track-mounted combination unit consists of 11 men, 1 loading machine, 1 cutting machine, 1 drill, 4 blowdown valves, a 3-inch compressed air shell, 1 roof-bolting machine, an 8-ton locomotive, and a push truck.

The cycle of operations is: Set safety posts and lay track, roof bolt, cut, drill, blast, and load coal.

Roof bolting is similar to the plan used in entry development. In addition, two rows of posts are set 3 and 6 feet from each rib. Props in rows 3 feet from the rib are set on 7-foot centers, and props in rows 6 feet from the rib are set on 3-foot centers.

The entries are bottom cut, are sheared on the right side, and are drilled, blasted, and rock dusted as described in the main-entry development. The rooms are cut just below the shale parting and sheared. In rooms, 10 blast holes, each 9 feet deep, are drilled; four holes are in the middle of the draw slate and are spaced 3 and 4 feet from the left rib and 3 and 4 feet from the right rib; four holes are 1 foot below the draw slate and are spaced 2 and 4 feet from the left rib and 2 and 4 feet from the right rib; and two holes are immediately above the 2-1/2-inch band and are spaced 8 feet from the left rib and 8 feet from the right rib. Blasting and rock dusting are done as in entry development. Rooms are driven 22 feet wide on 30-foot centers, and crosscuts 4 feet wide are staggered and driven on 80-foot centers.

The average advance in entries and rooms is about 10 feet per shift in each of the eight rooms and two entries for a total of 100 feet. A unit produces 443 tons of raw coal per shift, yielding 288 tons of clean coal based on a 35-percent reject in the cleaning plant. This is 40.3 tons of raw coal or 26.2 tons of clean coal per shift for each man in the unit crew. Loading and transportation of the cars are similar to the description in entry development. The unit crew comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper[1] | Do. |
| 1 Motorman | Do. |
| 2 Cutting machine men | Do. |
| 1 Driller | Do. |
| 1 Shotfirer | Do. |
| 1 Roof bolter | Do. |
| 1 Post man | Do. |
| 1 Trackman | Do. |
| Total.......... 11 men working | 11 shifts |

[1] Acts as brakeman also.

Face Face-haulage delays (25 minutes) of track-mounted equipment consisted of derailments and tramming loaded and empty cars to and from the storage track. Production delays (20 minutes) were caused by waiting on coal (face preparation). Other delays (45 minutes) consisted of waiting on empties from main line. Travel time required 50 minutes, lunch time was staggered; leaving 430 minutes for face time. Total face delays were 90 minutes, allowing 340 minutes' productive time per shift.

### Room Development With Track-Mounted Wide Units

A wide unit usually mines a group of 12 rooms on retreat after the combination unit has completed driving the butt entries and the room panel. A crew of six men (bull crew) neck the rooms to be mined by the wide units to 45-foot depths, and then the switches and track are installed by the tracklayers. This is done so that all equipment is off the entry and allows freedom of movement on the entry by the units to any of the rooms in the panel.

A track-mounted wide unit consists of 12 men, 1 loading machine, 1 cutting machine, a 4-ton chassis mounted drill, 6 blowdown valves, a 3-inch compressed air shell, 1 roof bolting machine, a 6-ton locomotive, and a push truck.

The cycle of operations is: Set safety posts and lay track, roof bolt, cut, drill, blast, and load coal. The roof bolting and timbering plan is similar to that described in room work of the combination unit.

Eleven blast holes, each 9 feet, are drilled in the face of the rooms as follows: Four are in the center of the draw slate spaced 3 and 4 feet from the left rib and 3 and 4 feet from the right rib; four are immediately below the draw slate spaced 2 and 4 feet from the left rib and 2 and 4 feet from the right rib; one is in the center above the 2-1/2-inch band; and two are about 16 inches above the bottom and are spaced 7 feet from the left rib and 7 feet from the right rib. Blasting and rock dusting are done as in entry development. Rooms are driven 22 feet wide on 30-foot centers, and crosscuts 4 feet wide are staggered and driven on 80-foot centers. (See fig. 26, p. 54, group 9.)

The average advance in rooms is 9 feet per shift or 108 feet in 12 rooms. A unit produces 608 tons of raw coal per shift, yielding 395 tons of clean coal. This is 50.7 tons of raw coal or 32.9 tons of clean coal per shift for each man in the unit crew, which comprises the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Motorman | Do. |
| 1 Brakeman | Do. |
| 2 Cutting machine men | Do. |
| 1 Driller | Do. |
| 1 Shotfirer | Do. |
| 1 Roof bolter | Do. |
| 1 Post man | Do. |
| 1 Trackman | Do. |
| Total........................ 12 men working | 12 shifts |

Face-haulage delays (10 minutes) of track-mounted equipment consisted of tramming loaded and empty cars to and from the storage track. Production delays (10 minutes) consisted of waiting on coal (face preparation). Other delays (20 minutes) consisted of waiting on empties from the main line. Travel time required 45 minutes, and lunch time was staggered, leaving 435 minutes for face time. Total face delays were 40 minutes, allowing 395 minutes' productive time per shift.

## Mine 10

This mine is operated in the Pittsburgh No. 8 coalbed which averages 77-1/4 inches thick in this area. Two shale partings one-fourth and one-half inch thick occur 38 inches and 38-3/4 inches above the bottom of the bed. (See fig. 27.) The top 6 inches of coal is left unmined except in the haulage entries where it is mined along with 13 inches of draw slate immediately above it. The draw slate is overlain with 10 inches of wild coal, 5 inches of draw slate, 8 inches of coal, and 17 feet of black shale. The overburden consists mainly of shales, limestones, sandstones, and several coalbeds, and averages 460 feet in thickness. The coalbed is underlain by 6 to 8 inches of shale that provides fair to good bottom when wet or dry. Clay veins are encountered in mining, and the bed has a regional dip of 1-1/2 percent to the west. Pillars are extracted on retreat.

The loaded mine cars are transported in 25 car trips by 30-ton tandem locomotives to a rotary dump at the foot of the belt slope. The main haulage track is 44-inch gage with 100-pound rail. The slope, 650 feet long on a 16-degree 30 minute pitch, is equipped with a 48-inch belt conveyor for transporting the coal to a surface preparation plant. A supply slope on an 18-degree pitch is used to deliver supplies and mining equipment to the mine. Men enter and leave the mine by elevator through a vertical shaft 468 feet deep.

The mine is operated three shifts per day and produces an average of 9,300 tons of raw coal that yields 7,161 tons of clean coal with the following units:

(a) 4 mobile-loading units, each with 2 shuttle cars to develop entries; 13-2/3 men in each unit (on the basis of assigned time per shift); 12 unit shifts per day;

(b) 2 track-mounted units to develop entries; 13-2/3 men in each unit (on the basis of assigned time per shift); 6 unit shifts per day;

(c) 7 mobile-loading units, each with 2 shuttle cars to extract entry pillars on retreat; 13-2/3 men in each unit (on the basis of assigned time per shift); 21 unit shifts per day;

(d) 2 track-mounted units to extract entry pillars on retreat; 13-2/3 men in each unit (on the basis of assigned time per shift); 6 unit shifts per day.

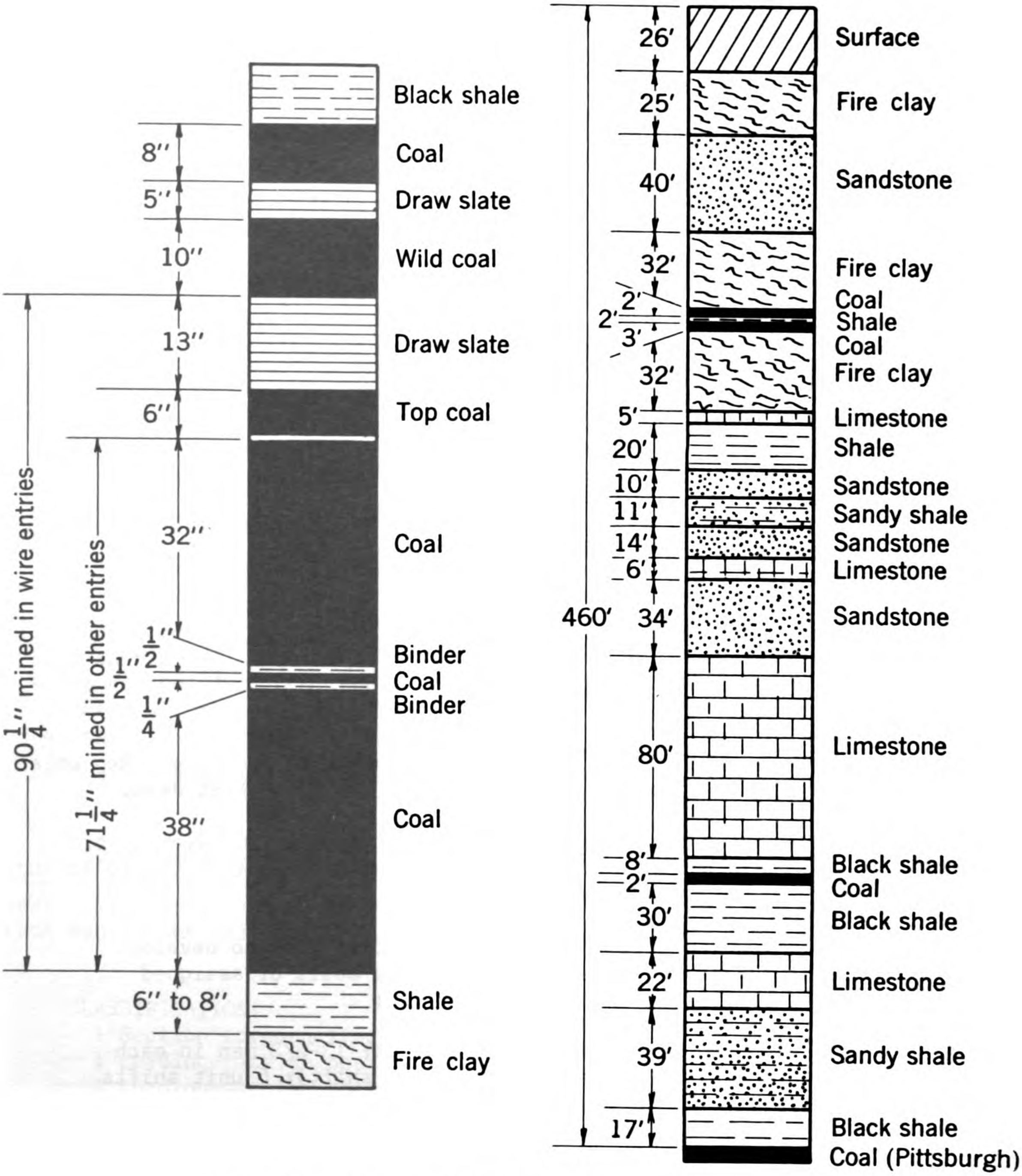

FIGURE 27. - Section of Coalbed and Overburden at Mine 10.

A detailed study was made of entry development using shuttle cars and mine cars to compare the two systems of face haulage.

## Developing Main Entries Using Shuttle Car Haulage

The mine is developed by a system of multiple entries. Main entries 14 feet wide are driven in sets of six and twelve on 80-foot centers with crosscuts 14 feet wide, turned on angles of 60 and 90 degrees on 80- and 100-foot centers. Panel entries 14 feet wide in sets of four to six on 80-foot centers, are turned 90 degrees from the mains on 560-foot centers and driven 1,500 feet. Crosscuts are driven 14 feet wide and are turned on an angle of 60 degrees on 100-foot centers. A barrier pillar 146 feet wide is maintained between each set of panel entries on advance and is extracted when the panels are retreated.

Two single units (double unit) are used to advance a set of entries. (See fig. 28.) Each of the single units consists of 13-2/3 men (on the basis of assigned time per shift), one loading machine, one cutting machine equipped with a hydraulic drill, one roof-bolting machine, two shuttle cars, and one 8-ton reel locomotive. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine on weekends.

The cycle of operations is: Set safety posts, roof bolt, drill and cut, blast, rock dust, and load coal.

Entries are roof bolted with 5/8-inch expansion shell-type bolts 72 inches long set 3 feet from either rib on 4-foot centers. The bolts are set against 6- by 6- by 1/4-inch steel plates. The draw slate above the coal is mined with the coal in the haulage entries. Six inches of top coal is left in the other entries.

All entries except the haulage entry are sheared on the left rib and top cut 6 inches below the draw slate. Three blast holes, each 9 feet deep, are drilled 1 foot above the bottom. One hole is drilled in the center of the entry, and one hole is drilled 1 foot from each rib. Each hole is charged with 4 or 5 sticks of permissible powder and blasted one at a time. The haulage entries are sheared on the left rib and are top cut immediately below the draw slate. Six blast holes, each 9 feet deep, are drilled in the face. Three holes are drilled 1 foot above the bottom and are spaced one in the center and one 1 foot from each rib. Three holes similarly spaced are drilled in the draw slate. Each hole is charged with 5 or 6 sticks of permissible powder and blasted one at a time.

The mined coal is loaded by the mobile-loading machine into two shuttle cars which transport and unload the coal into 8-ton capacity steel mine cars. The cars are spotted and moved at the loading ramp with an 8-ton locomotive. Loading ramps are moved every 200 feet of advance.

The average advance of each entry or entry and crosscut in a set of 12 entries is 12.2 feet per shift or 146.4 feet per shift for the group. Each unit produces 242 tons of raw coal per shift, yielding 186 tons of clean coal.

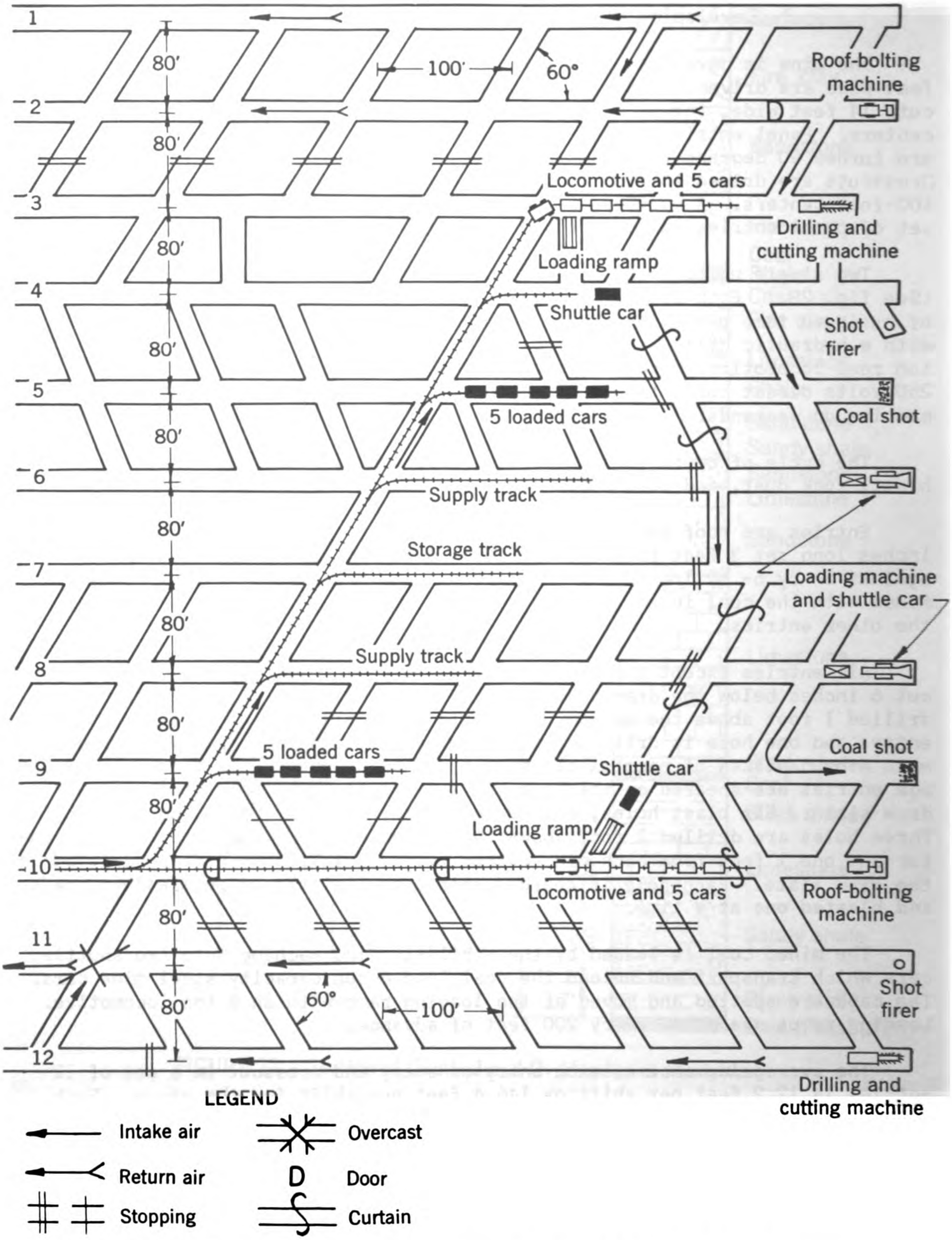

FIGURE 28. - Entry-Development Plan with Two Sets of Mobile-Loading Equipment, Each Using Two Shuttle Cars at Mine 10.

This is 17.7 tons of raw coal or 13.6 tons of clean coal per shift for each man in the unit crew. The unit crew consists of:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Cutting-machine operator | Do. |
| 1 Cutting-machine operator's helper | Do. |
| 1 Shotfirer | Do. |
| 2 Roof bolters | Do. |
| 2 Shuttle-car operators | Do. |
| 1 Bratticeman | Do. |
| 1 Timberman | Do. |
| 1 Mechanic | 2/3 |
| 1 Motorman | Full-time |
| Total ... 14 men working | 13-2/3 shifts |

Face-haulage delays (15 minutes) were caused by shuttle cars (mechanical). Production delays (30 minutes) were due to weak power (slow loading), 15 minutes; and mechanical repairs to the loading machine, 15 minutes. Other delays (75 minutes) resulted from the loading machine, 30 minutes; and waiting on empties, 45 minutes. Travel time required 120 minutes, and lunch time was staggered, leaving 360 minutes for face time. Total face delays were 120 minutes, allowing 240 minutes' productive time per shift.

## Developing Panel Entries Using Mine-Car Haulage

Four to six entries 14 feet wide on 80-foot centers are driven 1,500 feet. Crosscuts are driven 14 feet wide and are turned on an angle of 60 degrees on 100-foot centers. (See fig. 29.)

A unit consists of 13-2/3 men (on the basis of assigned time per shift), one tractor-mounted loading machine, one track-mounted cutting machine equipped with a hydraulic drill, one rubber-tired mounted roof-bolting machine, one truck (tracklayers), and one 8-ton reel locomotive. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by hand on shift and with a machine on weekends.

The cycle of operations is: Set safety posts, lay track, roof bolt, drill and cut, blast, rock dust, and load coal.

Entries are roof bolted with 5/8-inch expansion shell-type bolts 72 inches long set 3 feet from either rib on 4-foot centers. The bolts are set against 6- by 6- by 1/4-inch steel plates. The draw slate above the coal is mined with the coal in the haulage entry. Six inches of top coal is left in the other entries. All entries except the haulage entry are sheared on the left rib and are top cut 6 inches below the draw slate. Three blast holes, each 9 feet deep, are drilled 1 foot above the bottom. One hole is drilled in the center of the entry and one is drilled 1 foot from each rib. Each hole is

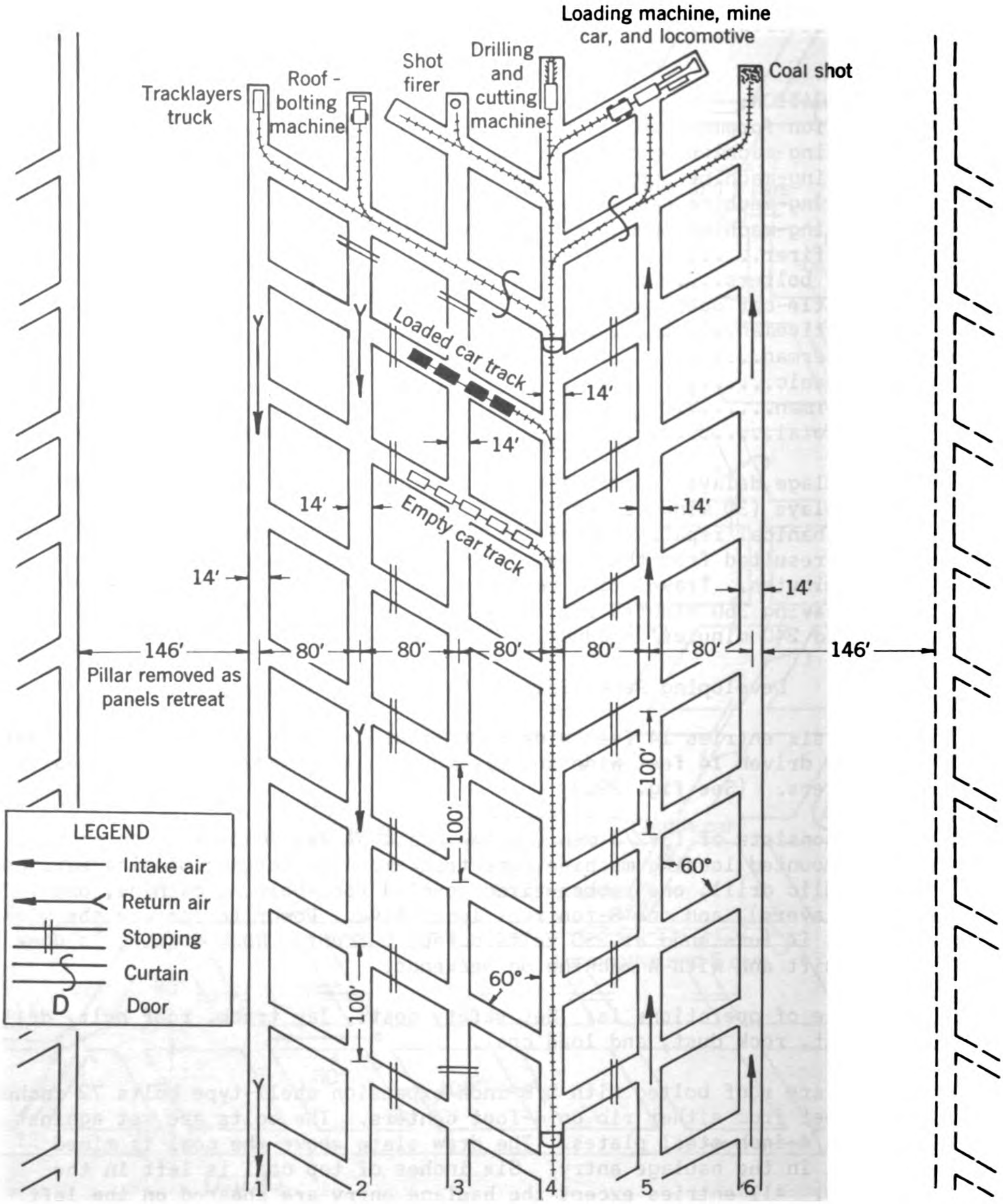

FIGURE 29. - Entry-Development Plan with Track-Mounted Equipment Using Mine Cars at Mine 10.

charged with four or five sticks of permissible powder and blasted one at a time. The haulage entry is sheared on the left rib and is top cut immediately below the draw slate. Six blast holes, each 9 feet deep, are drilled in the face. Three holes are drilled 1 foot above the bottom and are spaced one in the center and one 1 foot from each rib. Three similarly spaced holes are drilled in the draw slate. Each hole is charged with five or six sticks of permissible powder and blasted one at a time.

The mined coal is loaded by a mobile-loading machine into 8-ton capacity steel mine cars which are loaded and trammed to a nearby storage track by an 8-ton locomotive. When 10 cars have been loaded, they are trammed to a gathering station by the locomotive which then returns with 10 empty cars to the working section. Transportation of the loaded cars from the gathering station is similar to that described for mobile-loading units in entries using shuttle car haulage.

The average advance of each entry or entry and crosscut in a set of six entries is 9.0 feet per shift or 54 feet per shift for the group. A unit produces 167 tons of raw coal per shift, yielding 129 tons of clean coal. This is 12.2 tons of raw coal or 9.4 tons of clean coal per shift for each man in the unit crew, which comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Cutting-machine operator | Do. |
| 1 Cutting-machine operator's helper | Do. |
| 1 Shotfirer | Do. |
| 2 Roof bolters | Do. |
| 2 Trackmen | Do. |
| 1 Timberman | Do. |
| 1 Mechanic | 2/3 |
| 1 Motorman | Full-time |
| 1 Brakeman | Do. |
| Total 14 men working | 13-2/3 shifts |

Face-haulage delays (100 minutes) of track-mounted equipment resulted from waiting for empties. Production delays (20 minutes) consisted of waiting on coal and derailing. Other delays were not charged. Travel time required 50 minutes, and lunch took 30 minutes, leaving 400 minutes for face time. Total face delays were 120 minutes, leaving 280 minutes' productive time per shift.

## Mine 11

This mine is operated in the No. 6 Illinois coalbed which averages 84 inches thick in the area. A parting of shale (blue band), 1 inch thick, occurs 12-1/2 inches above the bottom. (See fig. 30.) Thin bands of pyrite are present but are not persistent in occurrence or position in the bed. The bed is

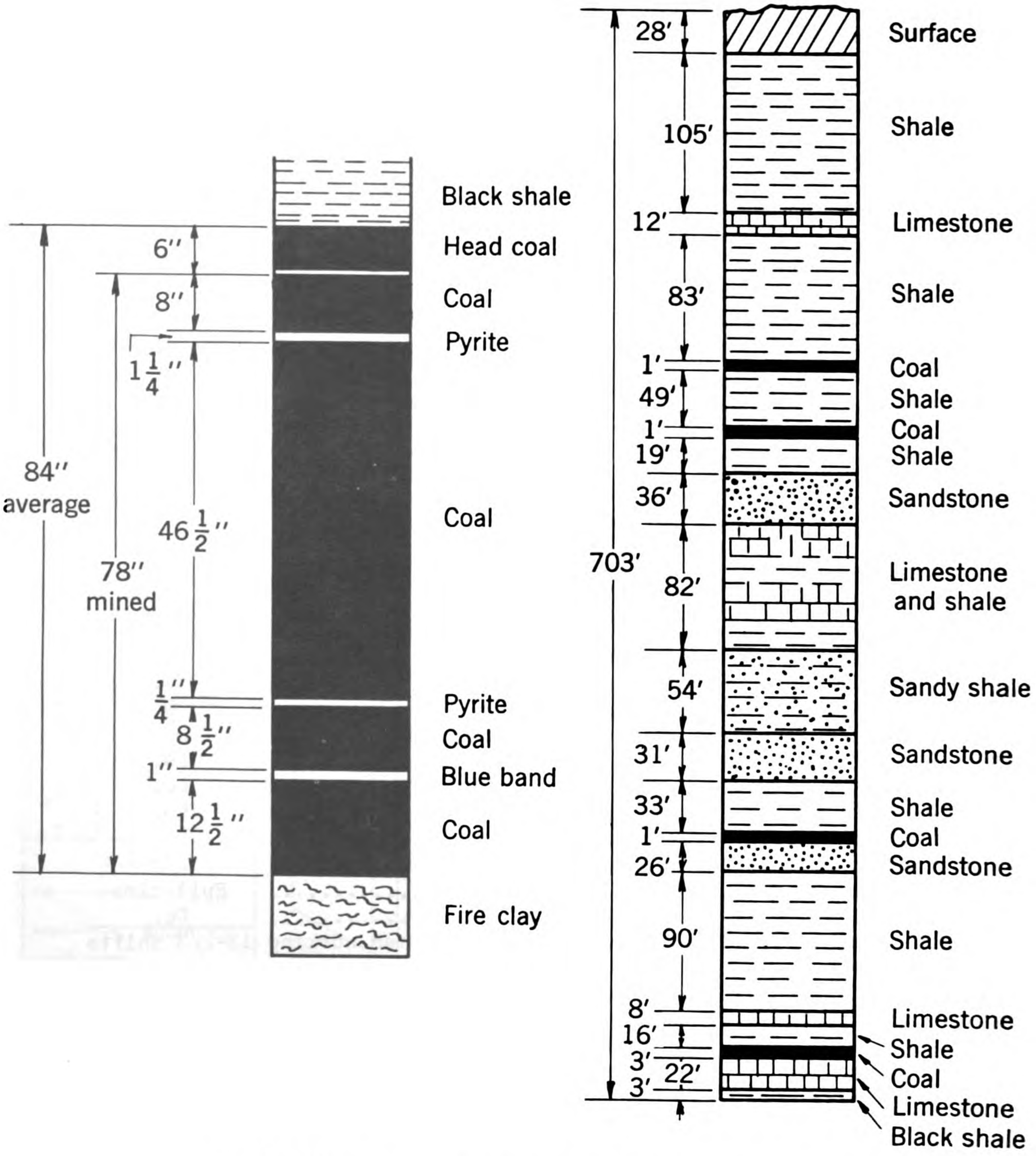

**FIGURE 30. - Section of Coalbed and Overburden at Mine 11.**

underlain by fire clay and overlain with 3 or more feet of black shale that provides good to fair roof. The overburden consists mainly of limestones, shales, sandstones, several thin coal beds, and averages 703 feet thick.

The loaded mine cars are hauled by 20-ton locomotives in 15 car trips over 42-inch gage (80-pound rail) track to an automatic dump with a 200-ton capacity bin at the foot of the vertical hoisting shaft. The coal then is fed automatically into two 8-ton capacity skips, is hoisted 700 feet to the surface, is dumped, and is conveyed by belt to the preparation plant. Men and supplies enter and leave the mine by cage through a separate vertical shaft.

The mine is operated two shifts a day, except for one three-shift-a-day unit, and produces an average of 11,600 tons of raw coal that yields 10,672 tons of clean coal. The following units are used:

(a) 2 boring type continuous-mining units, each with an extensible belt conveyor for mining rooms 12-1/2 feet wide; 7-3/4 men in each unit (on the basis of assigned time per shift);[1] [2] 2 shifts per day;

(b) 1 slabbing unit (mobile loading) with 2 shuttle cars for widening rooms to 29 feet (driven with continuous-mining units); 16-1/2 men in each unit;[2] 2 shifts per day;

(c) 2 mobile-loading units, each with 2 shuttle cars for developing entries; 20 men in each unit, 2 shifts per day;

(d) 1 mobile-loading unit with 2 shuttle cars for developing panel entries; 20 men in each unit; 3 shifts per day;

(e) 1 mobile-loading unit with 2 shuttle cars for developing entries and mining rooms; 20 men in each unit; 2 shifts per day.

---

[1] Mechanic prorated between two units.

[2] Beltman prorated; 1/2 for continuous-mining units and 1/2 for mobile-loading units.

All main entry and panel development is done with mobile-loading equipment. Main entries 16 feet wide in sets of five are driven on 60-foot centers with crosscuts 16 feet wide on 74-foot centers. Panel entries in the mobile-loading sections are turned in sets of three at 900-foot intervals and are driven 16 feet wide on 60-foot centers to a depth of 1,500 feet. Rooms turned from both sides of the panel are driven 24 to 28 feet wide on 50-foot centers to a depth of 295 feet. Panel entries in the continuous mining and slabbing sections are turned in sets of three at intervals of 1,350 feet and are driven 14 feet wide on 50-foot centers to a depth of 1,500 feet. Room necks 16 feet wide on 50-foot centers are driven 40 to 50 feet deep as the two outside entries are advanced. The entries and room necks are bolted with 5/8-inch expansion shell-type bolts 4 and 6 feet long spaced 4 feet apart in rows 4 feet apart. Bolts are set against 4- by 4- by 3/8-inch steel-bearing plates which are set against 2- by 10- by 15-inch wood headers. The middle entry is equipped with a 42-inch rope-type belt, which conveys the mined coal to the car-loading station on the cross entries.

A detailed study was made of the two boring type continuous-mining units with extensible belts and of the slabbing (mobile-loading) unit with shuttle cars to compare the two systems of face haulage.

With continuous-mining units, rooms are driven 600 feet long and 12-1/2 feet wide on 50-foot centers with crosscuts 12-1/2 feet wide on 300-foot centers. (See fig. 31.) Mining of rooms is done on advance on one side of the panel and on retreat on the other. Whenever possible, in completing the mining in two rooms, the first machine to move to the next location leaves a room space for the second machine. Bv so doing, the crew does not need to disconnect the continuous belt of the first unit to permit passage of the second machine to its new location.

Each continuous-mining unit consists of 7-3/4 men (on the basis of assigned time per shift), one boring type continuous-mining machine, 1 extensible belt, 1 belt winder, 1 blower fan with 12-inch spiral ventilating tubes, and one wet rock-dust applicator. A 42-inch panel belt and a car spotter hoist are used by the continuous-mining units and the slabbing unit for intermediate haulage. Power to operate the equipment is furnished at 250 volts direct current.

The blower fan powered by a 5-horsepower motor and using 12-inch spiral ventilating tube (25-foot sections) is installed on the intake side of each room, either in a room neck on the entry or in the crosscut after the room has advanced beyond 300 feet. About 3,500 cubic feet of air is delivered by the ventilating tube which is suspended from the roof and is kept within 20 feet of the continuous-mining machine. The wet rock-dust applicator machine is used on shift and has a maximum discharge of 1,200 feet from the machine.

The continuous-mining machine transfers the mined coal to the bridge conveyor which in turn loads coal on the 36-inch extensible belt. The coal is transferred to a 42-inch (rope) belt in the center entry which discharges the coal into 8-ton capacity bottom dump steel mine cars on the cross entries.

The average advance of each boring-type continuous-mining machine is 180 feet per shift. Each unit produces 550 tons of raw coal per shift, yielding 506 tons of clean coal based on a reject of 8 percent in the cleaning plant. This is 71.0 tons of raw coal or 65.3 tons of clean coal per shift for each man in the unit crew. The unit crew comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 2 Continuous-mining machine operators | Do. |
| 2 Tailpiece operators | Do. |
| 1 Wireman and utility | Do. |
| 1 Mechanic | [1] 1/2 |
| 1 Rock duster | Full-time |
| 1 Beltman | [1] 1/4 |
| Total ... 9 men working | 7-3/4 shifts |

[1] Prorated between units.

Face-haulage delays (55 minutes) were for lengthening extensible belt, 20 minutes; and retracting belt and moving to next location, 35 minutes.

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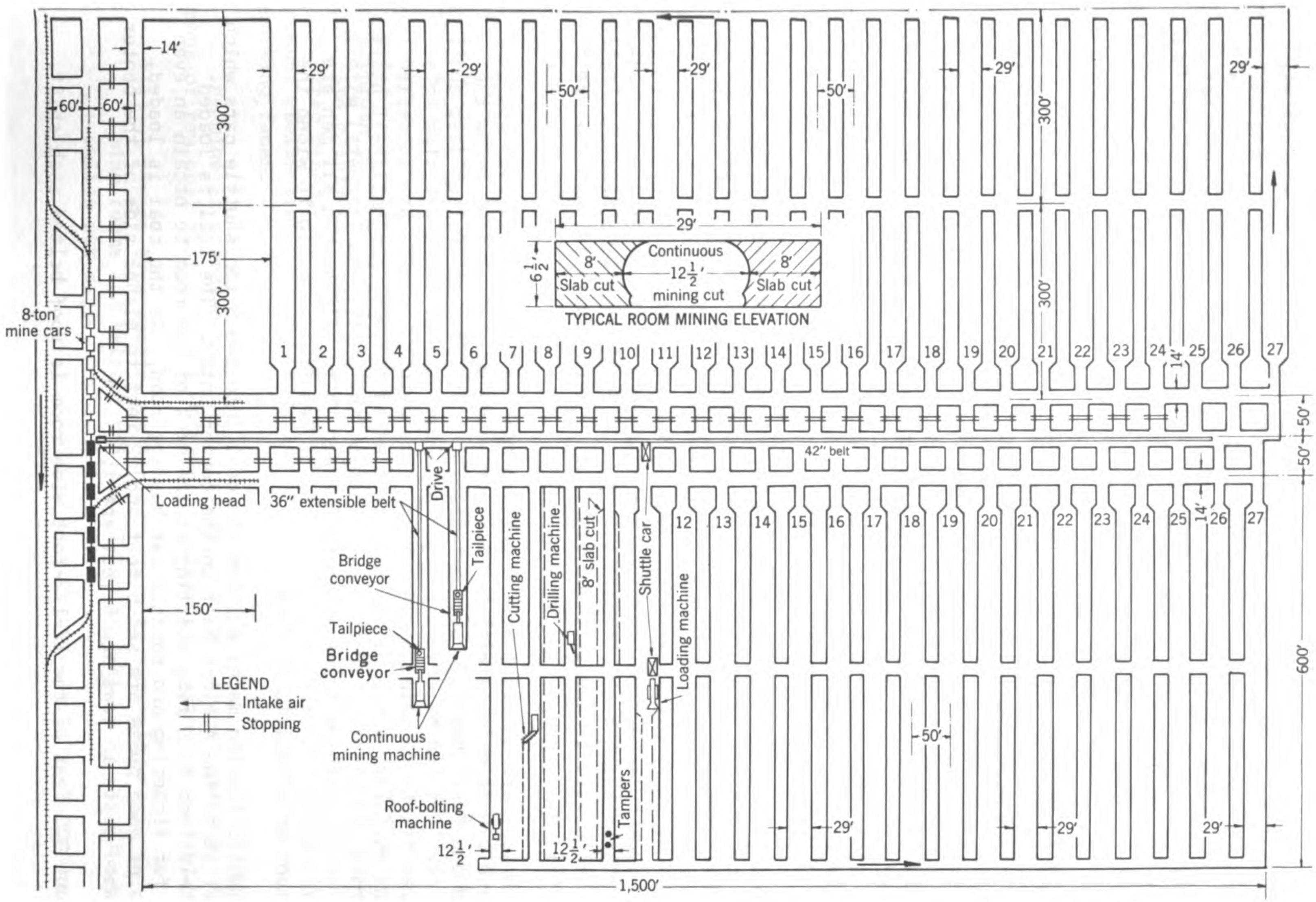

FIGURE 31. - Room-Mining Plan with Two Continuous-Mining Machines Using Two Extensible Belts and with a Mobile-Loading Unit Using Two Shuttle Cars at Mine 11.

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Production delays (60 minutes) resulted from mechanical difficulties of the continuous-mining machine. Other delays, moving the continuous-mining machine from a finished room to a new room location, took 25 minutes. Travel time required 60 minutes, and lunch time was staggered, leaving 420 minutes for face time. Total face delays were 140 minutes, allowing 280 minutes' productive time per shift

## Slabbing Unit (Mobile-Loading)

One slabbing unit is assigned to the panel entry to widen the rooms driven bv the two continuous-mining units from 12-1/2 to 29 feet. This is done by taking an 8-foot slab cut off each rib of the room. (See fig. 31.)

A slabbing unit consists of 16-1/2 men (on the basis of assigned time per shift), one hydraulic roof drill, two universal cutting machines (one spare), two truck-mounted coal drills (one spare), two loading machines (one spare), three cable-reel shuttle cars (one spare), and one battery-powered shuttle car for supplies. This unit also uses the 42-inch panel belt and car spotter hoist used bv the two continuous-mining units. Power to operate the equipment is furnished at 250 volts direct current.

Usually five to seven rooms 12-1/2 feet wide are completed by the continuous-mining machines in advance of the slabbing unit. The usual cycle of operations is: Roof bolt, cut, drill, blast, load coal, and timber.

The continuous-mining machine leaves 6 inches of top coal which is bolted with 5/8-inch bolts 4 to 6 feet long set against 4- by 4- bv 3/8-inch steel-bearing plates which are set against 2- bv 10- by 15-inch wood headers. Bolts are set 2-1/2 feet to the left and right of center. Bolts in each row are 5 feet apart.

Both ribs are undercut with a cutting machine having an 11-foot cutter bar. Each rib is drilled with two rows of holes spaced one foot below the roof and one foot above the bottom. The holes are drilled 10 feet deep and 6 feet apart. The top holes are charged with two sticks, and the bottom holes with three sticks of permissible powder. The detonator leads are connected in groups of 40. Each group of 40 holes is blasted successively until all holes in the room are blasted. Blasting is done by the shotfirers (tampers) with a Titan blasting machine between the second and third shifts when all men are out of the mine. About 8 feet of coal is broken from each rib to widen the 12-1/2-foot wide room to 29 feet.

A mobile-loading machine loads the coal into two 8-ton shuttle cars which transport it to the 42-inch belt in the center entry. The coal is loaded alternately from each rib, starting at the neck of the room to obtain an even cleanup for timbering and shuttle car haulage road. As the coal is loaded, two rows of wood posts are set 6 feet and 12 feet to either side of the center line. Wood posts in rows are 6 feet apart.

About 300 feet of the 12-1/2-foot wide room is roof bolted each shift.

An average of 600 feet of room rib (one side) is undercut and drilled, and the holes are tamped by each cutting, drilling, and tamping crew (working in separate rooms) per shift. The loading-machine crew loads and cleans 275 feet of room (both sides) per shift or 1,100 tons of raw coal which yields 1,012 tons of clean coal based on a reject of 8 percent in the cleaning plant. This is 66.7 tons of raw coal or 61.3 tons of clean coal per shift for each man in the unit crew, which comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 2 Roof bolters | Do. |
| 2 Cutting machine men | Do. |
| 2 Drillers | Do. |
| 2 Tampers | Do. |
| 2 Loading machine men | Do. |
| 2 Shuttle-car operators | Do. |
| 2 Timbermen | Do. |
| 1 Bratticeman | Do. |
| 1 Beltman | 1/1/2 |
| Total ........................... 17 men working | 16-1/2 shifts |

1/ Prorated with continuous-mining units.

Face-haulage delays (30 minutes) consisted of mechanical repairs and maneuvering the shuttle cars. Production delays (40 minutes) were due to mechanical repairs and maneuvering the loading machine. Travel time required 60 minutes and lunch time was staggered, leaving 420 minutes for face time. Total face delays were 70 minutes, allowing 350 minutes' productive time per shift.

## Mine 12

This mine is operated in the flat lying Pittsburgh No. 8 bed which averages 96 inches thick in the area. (See fig. 32.) The bed has numerous pyritic intrusions and also clay veins that range from 1 to 20 feet or more in width. The top 8 to 12 inches is left unmined to provide good roof. The coal is underlain by soft fire clay and is overlain by 2 to 4 feet of draw slate. The overburden is 70 feet thick at the highwall, ranges up to 150 feet thick, and consists mainly of limestones, sandstones, shales, and one coal bed. The area was strip mined, and some augering was done before underground mining was begun. Belts transport the coal, and shuttle cars deliver supplies to the working faces.

The mine is operated two shifts per day and produces an average of 6,450 tons of raw coal that yields 6,000 tons of clean coal with the following units:

(a) 1 ripper-type continuous-mining unit with extensible belt to mine rooms and extract pillars; 7 men in each unit; 2 unit shifts per day;

(b) 1 ripper-type continuous-mining unit with 2 shuttle cars to extract entry pillars on retreat; 8 men in each unit; 2 unit shifts per day;

(c) 2 mobile-loading units, each with 2 shuttle cars to extract entry pillars on retreat; 12 men in each unit; 4 unit shifts per day;

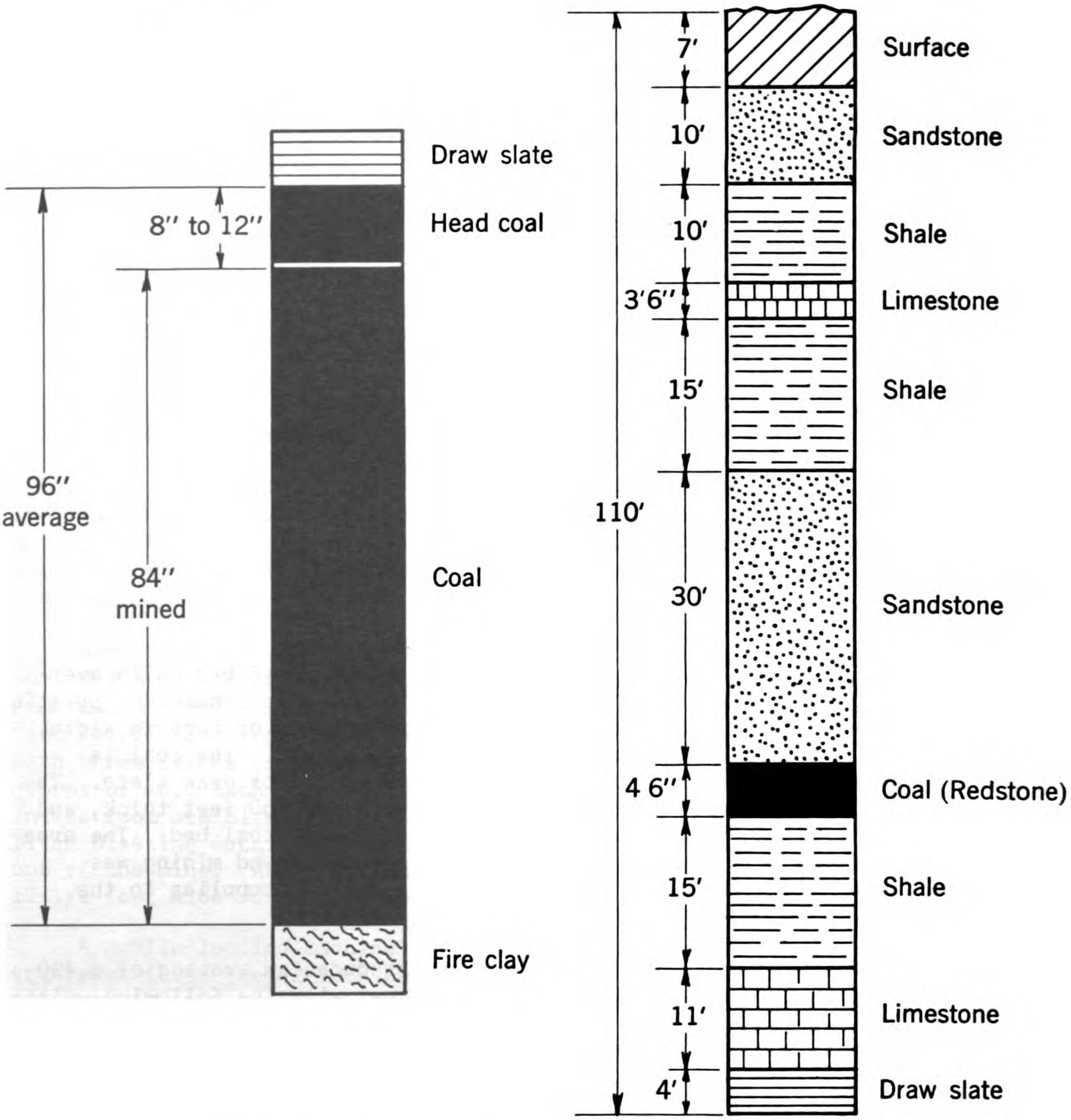

FIGURE 32. - Section of Coalbed and Overburden at Mine 12.

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(d) 3 mobile-loading units, each with 2 shuttle cars to develop entries; 12 men in each unit; 6 unit shifts per day.

To compare the three systems of face haulage, a detailed study was made of the continuous-mining unit with two extensible belts in rooms and extracting pillars; the continuous-mining unit with two shuttle cars extracting entry pillars; and the mobile-loading unit with two shuttle cars extracting entry pillars.

### Continuous-Mining Unit With Two Extensible Belts in Rooms

The mine was developed by a multiple system of entries. Entries were driven 14 feet wide in sets of 12 and 14 on 60-foot centers with crosscuts 14 feet wide on 60-foot centers. These entries were developed with conventional mining equipment and shuttle cars which discharged coal on 30- and 36-inch belts.

Rooms were driven with the continuous-mining unit 16 feet wide on 60-foot centers and 800 to 1,000 feet deep with crosscuts 16 feet wide on varying centers as projected.

Figure 33 shows room 13 developed to the mining limit with blind crosscuts 16 feet wide and 20 to 30 feet deep driven to the right on advance. The spare belt is left in room 13 as shown. The continuous-mining machine with tailpiece was detached from the belt and moved through the last open crosscut on the left, and the headpiece moved outby on the entry and attached to the belt that previously was left in room 12. The pillars on the left were extracted, and a 10- to 12-foot slab was mined from the pillars on the right side as the continuous-mining machine, tailpiece, and belt were retreated. Room pillars adjoining the entry are left in place. The entire unit (continuous-mining machine, tailpiece and headpiece, and extensible belt) was moved inby to room 14. After room 14 is developed to the mining limit, the procedure of moving to room 12 and mining the slab and pillars is followed for room 13.

A continuous-mining extensible belt unit consists of seven men, one ripper-type continuous-mining machine equipped with two roof-bolting machines, one 30-inch extensible belt unit with a spare belt, one pressure pump for supplying water for sprays on the continuous-mining machine, and two 30-inch panel belts. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done on shift when required and usually on weekends.

Eight to 12 inches of top coal is left for roof. Rooms and all splits and cuts in pillars are roof bolted with 5/8-inch expansion shell-type bolts 60 inches long. Two roof-bolting drills are mounted on the continuous-mining machine, one on each side. All bolts are set against 6- by 6- by 3/8-inch steel-bearing plates and where roof conditions require; the bearing plates are set against 2- by 6- by 18-inch wood headers.

As the continuous-mining machine advances or retreats, the extensible belt is extended or retracted by the mechanic assisted by the two utility men.

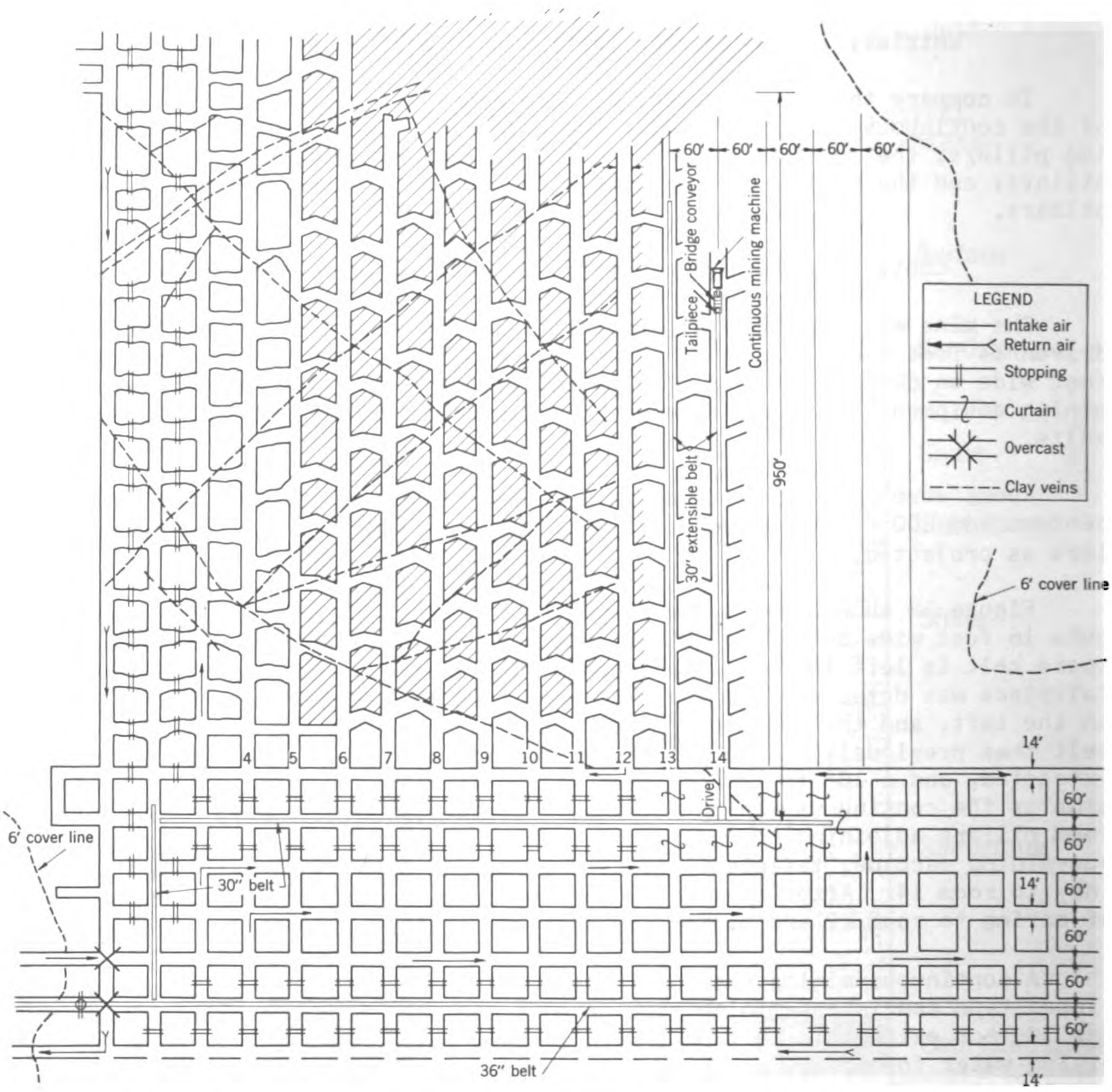

FIGURE 33. - Room-Mining Plan with a Continuous-Mining Machine Using Two Extensible Belts at Mine 12.

The mined coal is transferred from the extensible belt to a 30-inch panel belt and then to a short cross entry 30-inch belt that discharges the coal to the 36-inch main belt for delivery to the preparation plant.

The average advance in room and crosscuts is 120 feet per shift and about the same on retreat when extracting pillars. A unit produces 540 tons of raw coal or 502 tons of clean coal per shift with seven men. This is 77.1 tons of raw coal or 71.7 tons of clean coal for each man in the unit crew, which comprises:

| CLASSIFICATION: | | Assigned time per shift |
|---|---|---|
| 1 Section foreman | | Full-time |
| 1 Continuous-mining machine operator | | Do. |
| 2 Roof bolters | | Do. |
| 2 Utility men | | Do. |
| 1 Mechanic | | Do. |
| Total | 7 men working | 7 shifts |

Face-haulage delays (15 minutes) were due to extending the extensible belt, 11 minutes; and moving the extensible belt, 4 minutes (prorated). Production delays (45 minutes) consisted of waiting on continuous-mining machine (mechanical). Other delays (45 minutes) were caused by tramming the continuous-mining machine. Travel time required 30 minutes, and lunch time was staggered, leaving 450 minutes for face time. Total face delays were 105 minutes, leaving 345 minutes' productive time per shift.

## Continuous-Mining Unit With Two Shuttle Cars

Entry pillars are extracted on a flat or right angle line on retreat with a continuous-mining machine. (See fig. 34.) Usually one pillar at a time is extracted using the pocket-and-fender method. Cuts are 15 feet wide, and the fenders are holed through or recovered when possible. Breaker posts, when required, are set 1 foot apart in two or three rows to induce a break line in the caving roof.

A continuous-mining unit consists of eight men; two ripper-type continuous-mining machines (one for reserve), each equipped with two roof-bolting drills; three shuttle cars (one for reserve); two high-pressure pumps for water sprays on the continuous-mining machines (one for reserve); one rock-dusting machine; and two 30-inch belts. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done by machine on weekends.

The coalbed is about 82 inches thick in this section of the mine, and 8 to 10 inches of top coal is left as roof. All cuts, including splits in pillars, are roof bolted with 5/8-inch expansion shell-type bolts 60 inches long with two roof-bolting machines mounted one on each side of the continuous-mining machine. All bolts are set against 6- by 6- by 3/8-inch steel-bearing plates and where roof conditions require, the bearing plates are set against 2- by 6- by 18-inch wood headers.

The continuous-mining machine transfers the mined coal to the two shuttle cars that transport and load the coal on a 30-inch belt, which in turn loads coal on a 30-inch short cross-entry belt and then on a 30-inch main belt. The coal is conveyed to the surface and is dumped into a 40-ton capacity steel bin from where it is discharged on a short 30-inch belt which loads into trucks.

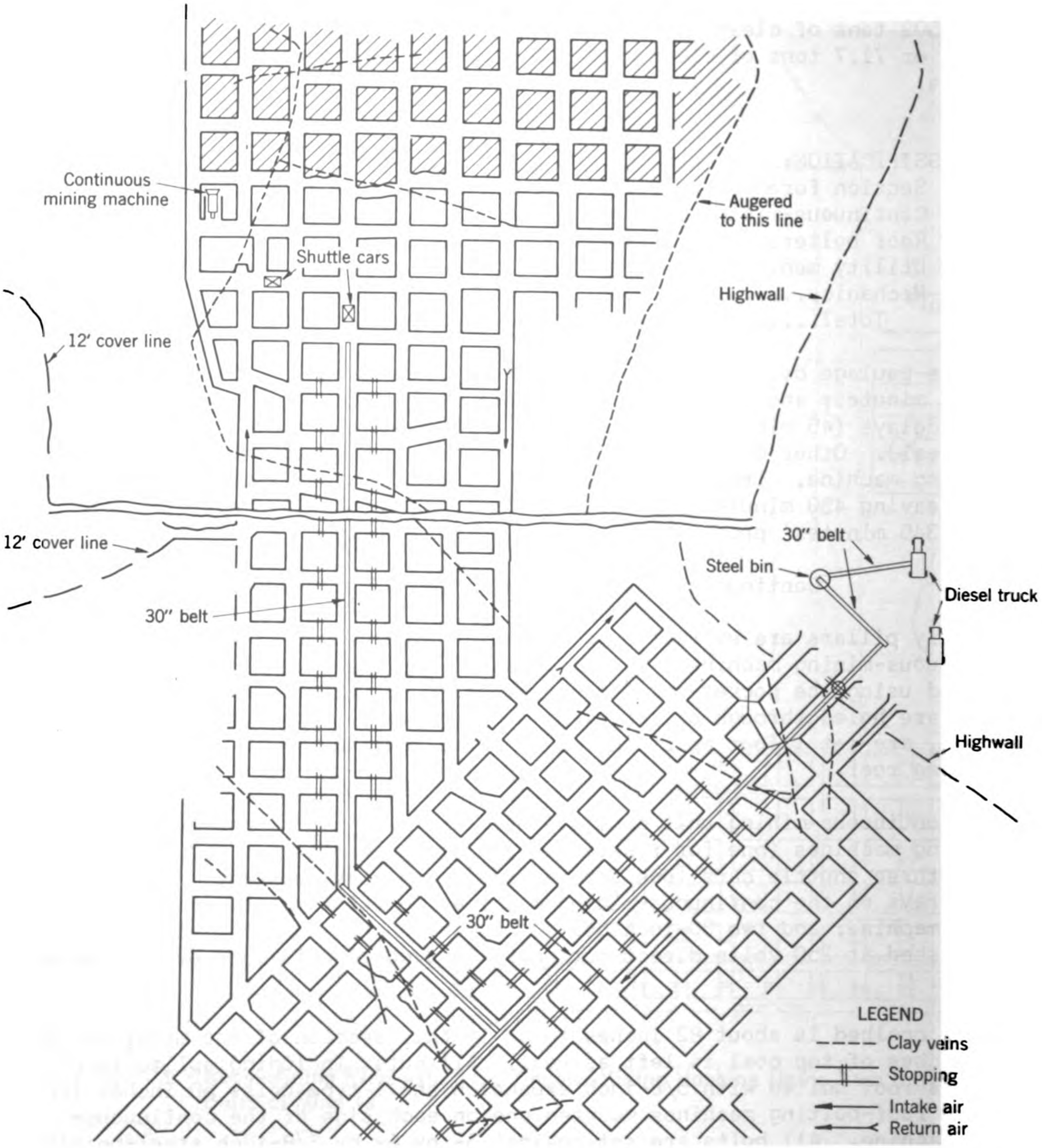

FIGURE 34. - Entry-Retreat-Mining Plan with a Continuous-Mining Machine Using Two Shuttle Cars at Mine 12.

Two 35-ton and four 20-ton capacity diesel-powered trucks, each working two shifts per day haul the coal about 4 miles and dump it into large bins from where the coal is transported by a 36-inch belt to the preparation plant.

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About 64 percent of a 46- by 46-foot pillar is removed each shift or the equivalent of a working place 95 feet long by 15 feet wide. A unit produces 325 tons of raw coal per shift, yielding 302 tons of clean coal. This is 40.6 tons of raw coal or 37.7 tons of clean coal per shift for each man in the crew, which comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Continuous-mining machine operator | Do. |
| 2 Roof bolters | Do. |
| 2 Shuttle-car operators | Do. |
| 1 Utility man | Do. |
| 1 Mechanic | Do. |
| Total........................... 8 men working | 8 shifts |

Face-haulage delays (30 minutes) concerned mechanical repairs of shuttle cars. Production delays (75 minutes) were caused by the continuous-mining machine (mechanical). Other delays (45 minutes) were due to tramming continuous-mining machine. Travel time was 20 minutes, and lunch time was staggered, leaving 460 minutes for face time. Total face delays were 150 minutes, allowing 310 minutes' productive time per shift.

### Mobile-Loading Units With Two Shuttle Cars Extracting Entry Pillars

Entry pillars are extracted on retreat with mobile-loading equipment. (See fig. 35.) Four to six places are prepared, and falls of coal always are available for the loading machine. Pillars are extracted on a 45-degree pillar line using the pocket-and-fender method. Cuts are 14 feet wide, and the fenders are holed through or recovered, where possible. Small pillars that are left and appear too large to crush are drilled and blasted to prevent overriding. Breaker posts, when required, are set 1 foot apart in two or three rows to induce a break line in the caving roof.

A mobile-loading unit consists of 12 men, 1 loading machine, 1 universal cutting machine, 1 roof-bolting machine with a hydraulic drill attachment, 2 shuttle cars, a high pressure pump (for water sprays on equipment), 1 rock-dusting machine, and a 30-inch belt. Power to operate the mining equipment is furnished at 250 volts direct current. Rock dusting is done on weekends.

The coalbed is 86 inches thick in this section, and 6 to 8 inches of the top coal is left for roof. All cuts and splits in pillars are roof bolted with 5/8-inch expansion-type bolts 60 inches long set against 6- by 6- by 3/8-inch steel-bearing plates. Where roof conditions require, the bearing plates are set against 2- by 6- by 18-inch wood headers. Bolts are set 3 feet from either rib on 4-foot centers in 14-foot-wide splits. Three blast holes, each 8-1/2 feet deep, are drilled 1 foot above the bottom and are spaced 1 foot to the right of the left rib, 1 foot to the right of center, and 3 feet to the left of the right rib. The coal is top cut and sheared on the right rib. Four to six sticks of permissible explosive are inserted in each hole by the

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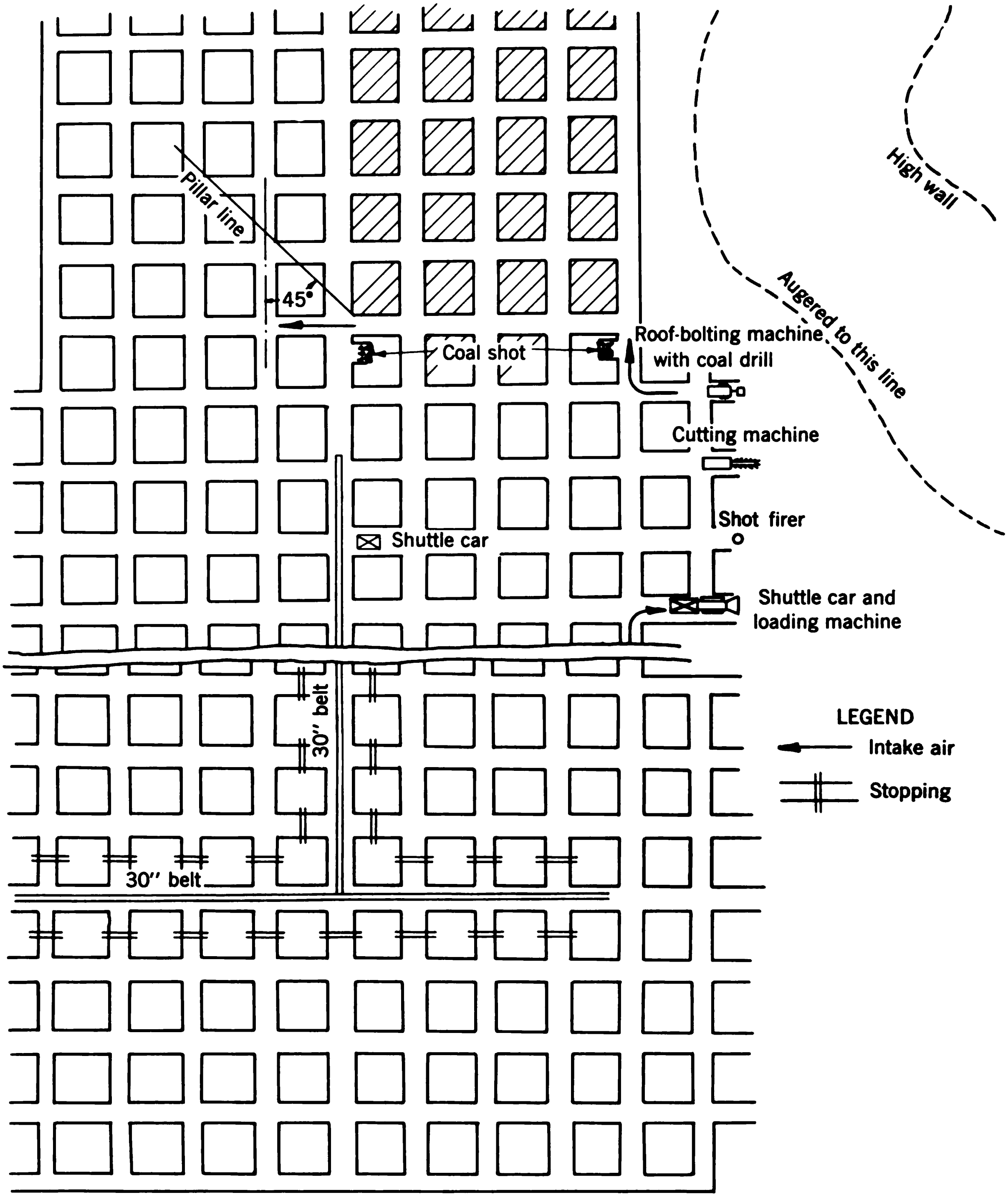

FIGURE 35. - Entry-Retreat-Mining Plan with Mobile-Loading Equipment Using Two Shuttle Cars at Mine 12.

shotfirer, and the holes are blasted one at a time. The loading machine loads into two shuttle cars which transport and dump the coal on a 30-inch belt which discharges the coal on a 30-inch main belt.

The equivalent of 86 percent of one 46- by 46-foot pillar or a working place 130 feet long by 14 feet wide is removed each shift. A unit produces 472 tons of raw coal per shift, yielding 439 tons of clean coal. This is 39.3 tons of raw coal or 36.6 tons of clean coal per shift for each man in the crew, which comprises:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Cutting-machine operator | Do. |
| 1 Cutting-machine operator's helper | Do. |
| 2 Roof bolters (also coal drillers) | Do. |
| 1 Shotfirer | Do. |
| 2 Shuttle-car operators | Do. |
| 1 Utility man | Do. |
| 1 Mechanic | Do. |
| Total 12 men working | 12 shifts |

No delays were chargeable to face haulage. Production delays (30 minutes) consisted of repairs to mobile-loading machine. Other delays were not charged. Travel time required 30 minutes, and lunch time was staggered, leaving 450 minutes for face time. Total face delays were 30 minutes, allowing 420 minutes' productive time per shift.

## Mine 13

Presently, one drift mine is operated in the Middle 5 Block bed, and two drift mines and a strip mine are operated in the Lower 5 Block bed. The underground mines, locally referred to as punch mines, are developed from the highwall of a strip mine when the overburden becomes too thick to be removed economically by the stripping equipment. These areas range from 600 to 2,000 feet long and 600 to 1,000 feet wide.

The mine is operated three shifts per day and produces an average of 4,286 tons of raw coal that yields 3,300 tons of clean coal with the following units:

(a) 1 mobile-loading unit with 3 shuttle cars to develop entries and mine rooms in Lower 5 Block bed; 11 men in each unit; 3 unit shifts per day;

(b) 1 mobile-loading unit with 4 shuttle cars dumping onto a 30-inch belt extracting room-and-entry pillars on retreat in Lower 5 Block bed; 15 men in each unit; 3 unit shifts per day:

(c) 1 mobile-loading unit with 5 shuttle cars extracting room-and-entry pillars on retreat in Middle 5 Block bed; 15 men in each unit; 3 unit shifts per day.

A detailed study was made of the unit developing entries and mining rooms in the Lower 5 Block bed. The bed is 84 inches thick and has a shale parting 4 inches thick 10 inches above the bottom, laminated coal 6 inches thick 14 inches above the bottom, and bone 6 inches thick 70 inches above the bottom. Only the 50 inches of coal 20 inches above the bottom is mined. (See fig. 36.)

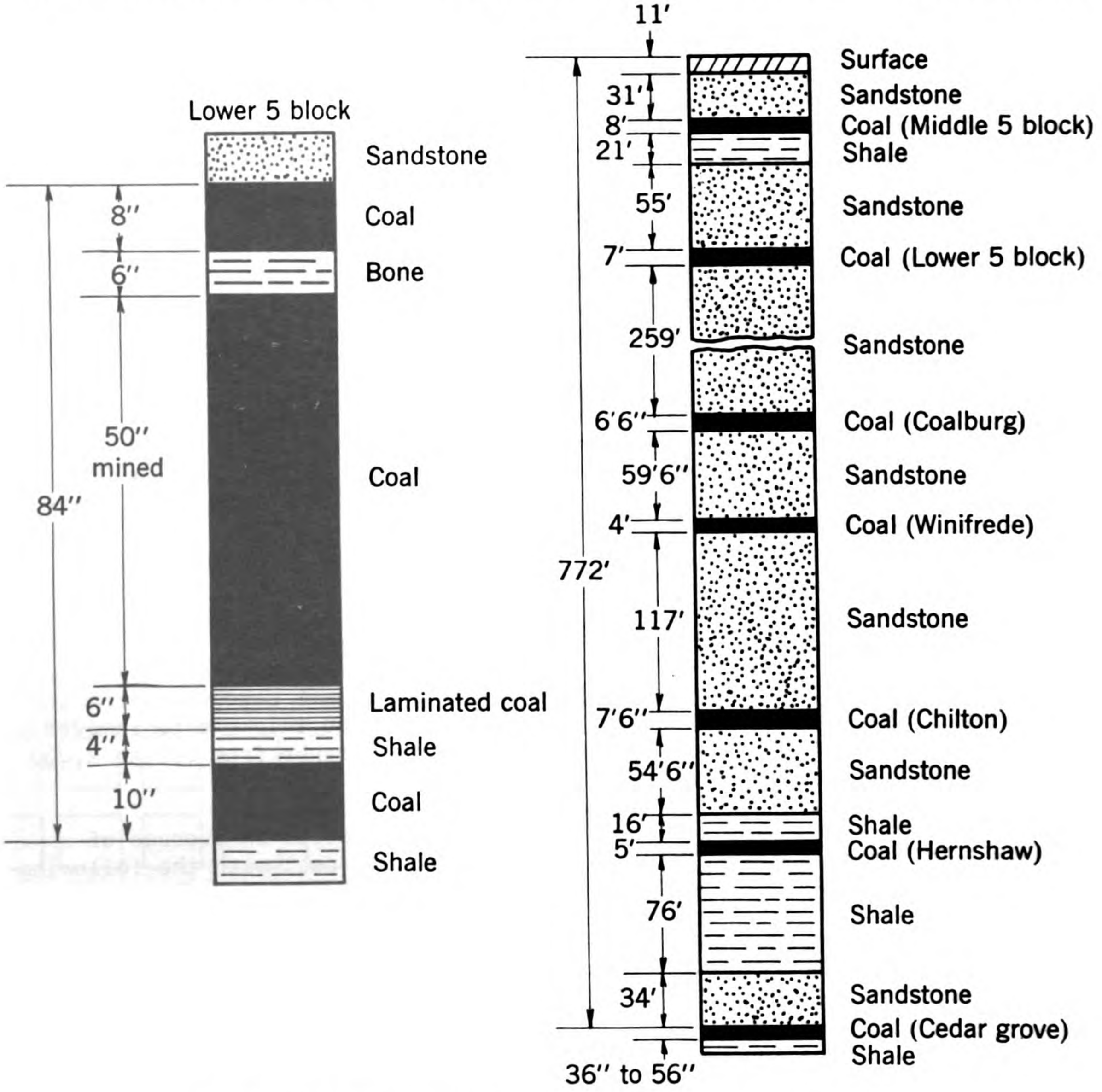

FIGURE 36. - Section of Coalbed and Overburden at Mine 13.

The bed is overlain by sandstone and is underlain by shale. The overburden consists of sandstone, shales, and a coalbed.

The mine is developed with four main entries 22 feet wide on 65-foot centers with crosscuts 18 feet wide on 100-foot centers and driven about 1,200 feet. Rooms 24 feet wide on 60-foot centers with crosscuts 18 feet wide are driven from the outside entries on the advance. (See fig. 37.)

A mobile-loading unit is used to advance the main entries and to mine rooms. Each unit consists of 11 men, 2 loading machines, 1 cutting machine with electric drill, 3 shuttle cars, 1 roof-bolting machine, and a 4-foot exhausting aeroplane-type fan. Power to operate the machines is furnished at 250 volts direct current by a 200-kilowatt motor generator set located on the surface. Rock dusting is done by hand on shift.

The cycle of operation is: Timber or roof bolt, rock dust, drill, cut, blast, and load coal. Entries are timbered with two rows of posts set 5 feet from either rib and on 4-foot centers except at the breakthroughs. These are roof bolted with 5/8-inch expansion shell-type bolts 36 and 60 inches long set in two rows 4 feet apart, each row set 5 feet from the rib line and with four bolts on 4-foot centers. The bolts are set against 6- by 6- by 1/4-inch steel plates, and these are set against 2- by 8- by 24-inch wood half headers. The four entries are advanced at the same time, and usually room mining is started after the entries have advanced several hundred feet. Entries are bottom cut and sheared 1 foot to the right of center. Four blast holes are drilled 8-1/2 to 9 feet deep, 4 inches below the roof, and 2 and 6 feet from the left rib and 2 and 5-1/2 feet from the right rib. Each hole is charged with 2 to 2-1/2 sticks of permissible powder, and all holes are detonated simultaneously.

The mined coal is loaded by a mobile-loading machine into 6-ton shuttle cars which transport it to a surface storage bank. Two elevating conveyors load the coal from the storage bank into 34-ton capacity diesel-powered trucks. Nine of these trucks are engaged three shifts per day to haul the mined coal from three drift mines to the preparation plant about 3 miles over rock-surfaced roads that are well maintained. The superintendent-dispatcher's truck and the maintenance superintendent's office, shops, and mine portals are equipped with two-way radio for rapid communication.

The average advance of each entry or entry and crosscut is 21.3 feet per shift or 85.2 feet for the four entries. A unit produces 351 tons of raw coal per shift, yielding 270 tons of clean coal. This is 31.9 tons of raw coal or 24.5 tons of clean coal for each man in the unit crew, which consists of the following:

| CLASSIFICATION: | Assigned time per shift |
|---|---|
| 1 Section foreman | Full-time |
| 1 Loading-machine operator | Do. |
| 1 Loading-machine operator's helper | Do. |
| 1 Cutting-machine operator | Do. |
| 1 Cutting-machine operator's helper (also drills) | Do. |

| CLASSIFICATION: (Con.) | | Assigned time per shift |
|---|---|---|
| 1 Shotfirer | | Full-time |
| 2 Shuttle-car operators | | Do. |
| 2 Timbermen (also roof bolters) | | Do. |
| 1 Mechanic | | Do. |
| Total | 11 men working | 11 shifts |

No delays were charged to face haulage, production, or other operations because of the extra equipment that was available for use when needed. Other delays (haulage) were not charged because of the extra shuttle cars that were available when needed. Travel time was not charged because of the short distance from mine portal to face, lunch time was 30 minutes, leaving 450 minutes for productive time.

## RESULTS OF STUDY

For this study, the 8-hour shift was standard at each mine. Time needed for travel to and from the face varied as did the scheduling of the 30-minute lunch. Travel and lunch time (unless the latter was staggered between unit crewmen) were deducted from the 480-minute shift to determine the minutes spent at the face. Face time ranged from 348 to 460 minutes. Productive time at the face depended on the various delays incurred. Table 2 summarizes the distribution of the work shift for 27 units studied at the 13 mines. Table 3 summarizes the distribution of time at the face in percent for the same units.

Four general types of face haulage were studied: Chain conveyors, extensible belts, shuttle cars, and mine cars. There were variations in equipment combinations used ahead of and behind the face haulage. Table 4 summarizes some of the results for each unit and shows the number of tons per crew and manshift. More complete summaries for each mine are given in appendix II.

No attempt was made when selecting the mines for study to select those with high production. Nor was there any intent to select the number of each type of face haulage in proportion to the number in use in all mines. Thus, averages of production per crew-manshift for any group might not reflect industrywide averages.

In comparing the four general systems of face haulage on a basis of tons per crew man per shift, the results were:

| Type of face haulage | Tons per man |
|---|---|
| Extensible belts | 53 |
| Shuttle cars | 30 |
| Mine cars | 30 |
| Chain conveyors | 21 |

As a group, extensible belt face haulage had the best average of production per crew manshift. This might be expected for several reasons: Each was behind a continuous-mining machine; the equipment was newer than most other

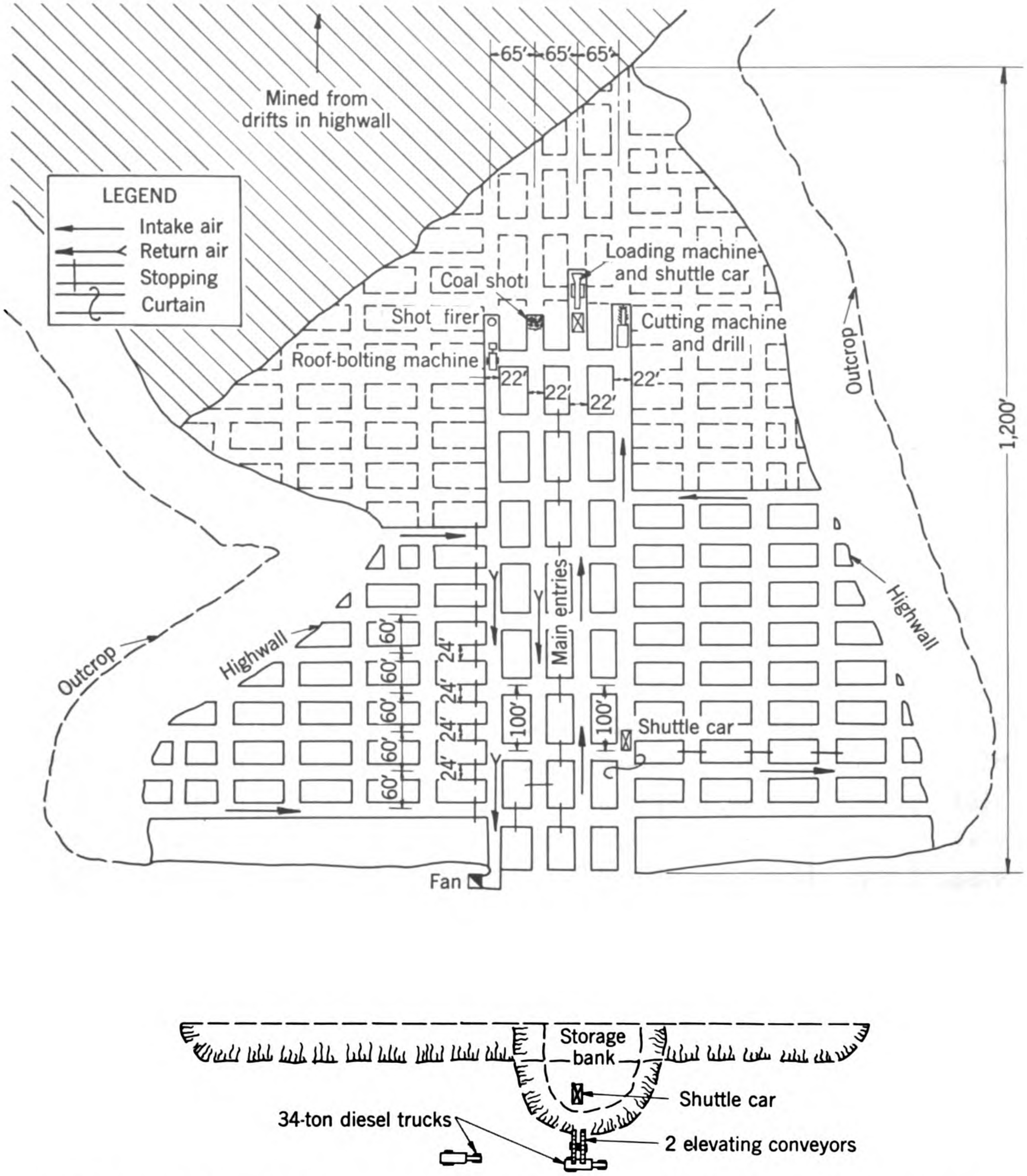

FIGURE 37. - Entry-Development and Room-Mining Plan with Mobile-Loading Equipment Using Two Shuttle Cars at Mine 13.

face haulage equipment; the delays attributable to face haulage generally were less than with other types; and the coalbeds in which they were operated were 52 inches or more in thickness.

TABLE 2. - Distribution of 8-hour shift

| Mine No. and unit | Time, minutes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Travel | Lunch | At face | Production delays | Face haulage delays | Other delays | Total delays | Production time |
| 1(a) | 40 | staggered | 440 | 30 | 84 | 90 | 204 | 236 |
| 2(a) | 15 | 30 | 435 | 45 | 75 | 15 | 135 | 300 |
| 3(a) | 60 | staggered | 420 | 62 | 27 | 47 | 136 | 284 |
| 3(b) | 36 | 30 | 414 | 87 | 15 | 72 | 174 | 240 |
| 4(a) | 60 | 30 | 390 | 25 | 5 | 60 | 90 | 300 |
| 4(b) | 60 | 30 | 390 | 26 | - | 70 | 96 | 294 |
| 4(c) | 60 | 30 | 390 | 30 | 35 | 55 | 120 | 270 |
| 5(a) | - | 30 | 450 | 60 | 14 | 60 | 134 | 316 |
| 6(a) | 62 | 30 | 388 | 143 | 40 | 40 | 223 | 165 |
| 6(b) | 64 | 30 | 386 | 136 | 29 | 30 | 195 | 191 |
| 6(c) | 55 | 30 | 395 | 45 | 15 | 35 | 95 | 300 |
| 6(d) | 102 | 30 | 348 | 95 | 85 | 41 | 221 | 127 |
| 7(a) | 75 | 30 | 375 | 30 | 13 | 90 | 133 | 242 |
| 7(b) | 60 | staggered | 420 | 23 | 20 | 71 | 114 | 306 |
| 8(a) | 20 | do. | 460 | 60 | 30 | 90 | 180 | 280 |
| 8(b) | 50 | do. | 430 | 60 | 30 | 90 | 180 | 250 |
| 9(a) | 60 | do. | 420 | 20 | 20 | 50 | 90 | 330 |
| 9(b) | 50 | do. | 430 | 20 | 25 | 45 | 90 | 340 |
| 9(c) | 45 | do. | 435 | 10 | 10 | 20 | 40 | 395 |
| 10(a) | 120 | do. | 360 | 30 | 15 | 75 | 120 | 240 |
| 10(b) | 50 | 30 | 400 | 20 | 100 | - | 120 | 280 |
| 11(a) | 60 | staggered | 420 | 60 | 55 | 25 | 140 | 280 |
| 11(b) | 60 | do. | 420 | 40 | 30 | - | 70 | 350 |
| 12(a) | 30 | do. | 450 | 45 | 15 | 45 | 105 | 345 |
| 12(b) | 20 | do. | 460 | 75 | 30 | 45 | 150 | 310 |
| 12(c) | 30 | do. | 450 | 30 | - | - | 30 | 420 |
| 13(a) | - | 30 | 450 | - | - | - | - | 450 |

TABLE 3. - Distribution of time at face

| | | Percent of face time | | | | | |
|---|---|---|---|---|---|---|---|
| Mine No. and unit | Time at face, minutes | Production delays | Face haulage delays | Other delays | Total delays | Total production time | Tons per manshift |
| 1(a) | 440 | 7 | 19 | 20 | 46 | 54 | 20 |
| 2(a) | 435 | 10 | 17 | 4 | 31 | 69 | 30 |
| 3(a) | 420 | 15 | 6 | 11 | 32 | 68 | 16 |
| 3(b) | 414 | 21 | 4 | 17 | 42 | 58 | 19 |
| 4(a) | 390 | 6 | 1 | 16 | 23 | 77 | 54 |
| 4(b) | 390 | 7 | - | 18 | 25 | 75 | 24 |
| 4(c) | 390 | 8 | 9 | 14 | 31 | 69 | 38 |
| 5(a) | 450 | 13 | 3 | 14 | 30 | 70 | 43 |
| 6(a) | 388 | 37 | 10 | 10 | 57 | 43 | 15 |
| 6(b) | 386 | 35 | 8 | 8 | 51 | 49 | 17 |
| 6(c) | 395 | 11 | 4 | 9 | 24 | 76 | 20 |
| 6(d) | 348 | 27 | 24 | 12 | 63 | 37 | 16 |
| 7(a) | 375 | 8 | 4 | 24 | 36 | 64 | 33 |
| 7(b) | 420 | 5 | 5 | 17 | 27 | 73 | 22 |
| 8(a) | 460 | 13 | 6 | 20 | 39 | 61 | 36 |
| 8(b) | 430 | 14 | 7 | 21 | 42 | 58 | 26 |
| 9(a) | 420 | 5 | 5 | 12 | 22 | 78 | 32 |
| 9(b) | 430 | 5 | 6 | 10 | 21 | 79 | 40 |
| 9(c) | 435 | 2 | 2 | 5 | 9 | 91 | 51 |
| 10(a) | 360 | 8 | 4 | 21 | 33 | 67 | 18 |
| 10(b) | 400 | 5 | 25 | - | 30 | 70 | 12 |
| 11(a) | 420 | 14 | 13 | 6 | 33 | 67 | 71 |
| 11(b) | 420 | 10 | 7 | - | 17 | 83 | 67 |
| 12(a) | 450 | 10 | 3 | 10 | 23 | 77 | 77 |
| 12(b) | 460 | 16 | 7 | 10 | 33 | 67 | 41 |
| 12(c) | 450 | 7 | - | - | 7 | 93 | 39 |
| 13(a) | 450 | - | - | - | - | 100 | 32 |

TABLE 4. - Summary of production per unit-crew/manshift

| Mine No. and unit | Type of face haulage | Face mining equipment | Thickness of coal mined, inches | Minutes face haulage delays | Minutes production time | Tons per shift | |
|---|---|---|---|---|---|---|---|
| | | | | | | Crew | Man |
| 4(a) | Extensible belt.......... | Ripper C.M.1/ | 52 | 5 | 300 | 324 | 54 |
| 5(a) | Do.................... | Boring C.M.2/ | 52 | 14 | 316 | 300 | 43 |
| 7(a) | Do.................... | Ripper C.M.1/ | 62 | 13 | 242 | 200 | 33 |
| 11(a) | Do.................... | Boring C.M.2/ | 78 | 55 | 280 | 550 | 71 |
| 12(a) | Do.................... | Ripper C.M.1/ | 84 | 15 | 345 | 540 | 77 |
| 12(b) | Do.................... | do. | 84 | 30 | 310 | 325 | 41 |
| 4(b) | Surge (car) - shuttle car.................... | do. | 52 | - | 294 | 170 | 24 |
| 4(c) | Do.................... | do. | 52 | 35 | 270 | 267 | 38 |
| 6(a) | Surge (floor) - shuttle car.................... | do. | 98 | 40 | 223 | 114 | 15 |
| 8(a) | Do.................... | do. | 65 | 30 | 280 | 255 | 36 |
| 7(b) | Shuttle car (to mine car).................... | M.L.3/ | 74 | 24 | 306 | 200 | 22 |
| 8(b) | Do.................... | do. | 65 | 26 | 250 | 255 | 26 |
| 10(a) | Do.................... | do. | 71 | 18 | 240 | 242 | 18 |
| 6(b) | Shuttle car (to belt).... | Ripper C.M.1/ | 51 | 29 | 191 | 114 | 17 |
| 6(c) | Do.................... | M.L.3/ | 98 | 15 | 300 | 159 | 20 |
| 11(b) | Shuttle car (to mine car).................... | do. | 78 | 67 | 350 | 1,100 | 67 |
| 12(c) | Shuttle car (to belt).... | do. | 84 | 15 | 420 | 472 | 39 |
| 13(a) | Shuttle car (only)....... | do. | 50 | - | 450 | 351 | 32 |
| 6(d) | Mine cars - locomotives.. | T.L.4/ | 72 | 85 | 127 | 136 | 16 |
| 9(a) | Do.................... | do. | 74 | 20 | 330 | 323 | 32 |
| 9(b) | Do.................... | do. | 74 | 25 | 340 | 443 | 40 |
| 9(c) | Do.................... | do. | 74 | 10 | 395 | 608 | 51 |
| 10(b) | Do.................... | do. | 71 | 100 | 280 | 167 | 12 |
| 1(a) | Bridge - chain conveyor.. | Auger C.M.5/ | 30 | 84 | 236 | 100 | 20 |
| 2(a) | Do.................... | do. | 42 | 75 | 300 | 135 | 30 |
| 3(a) | Do.................... | M.L.3/ | 36 | 27 | 284 | 137 | 16 |
| 3(b) | Chain conveyor.......... | do. | 56 | 15 | 240 | 172 | 19 |

1/ Ripper continuous miner.
2/ Boring continuous miner.
3/ Mobile loader.
4/ Track loader.
5/ Shortwall auger continuous miner.

Although the average production per crew manshift was the same for shuttle-car and mine-car haulages, shuttle-car haulage is more widely used and generally should give better results. Supervision and planning are important factors in the success or failure of these types of face haulage.

The shuttle-car haulage average is based on results from 12 units in 7 mines compared with 5 units in 3 mines for mine-car haulage. The minimum thickness of coal mined where mine-car haulage was studied was 71 inches whereas with shuttle cars, 6 of the 12 units were operated in coal of less thickness.

All shuttle cars were cable-reel type and were used with varied equipment both at the loading and unloading points. Loading of the shuttle cars was by surge car, a loading machine using the mine floor as surge capacity, and directly from a loading machine at the face. Unloading was to mine cars, belts, and storage outside the mine.

Delays caused by shuttle-car haulage were longer than by extensible belt. Principal delays were caused by mechanical defects of the shuttle cars and trailing-cable troubles. The largest production was 67 tons per crew manshift with shuttle-car face haulage made by the unusual slabbing unit (b) at Mine 11.

Mine-car face haulage that has been replaced largely by shuttle cars in coal mining had a surprisingly high average production per crew manshift. Actually, at only one of three mines studied using mine-car face haulage was the production comparable with that from shuttle cars. The face-haulage delays at Mine 9 were kept at less than one-half hour per shift, giving a correspondingly longer face-production time. At the other two mines using mine-car face haulage, the haulage delays were 85 and 100 minutes, leaving only 127 and 280 minutes for production of 16 and 12 tons per crew manshift.

Chain conveyors were most adaptable for use in coal beds less than 42 inches thick. Because of low headroom, the movement of equipment and personnel is more limited than in thick coal and results in less production per manshift. When used with bridge conveyors from the face equipment, production from chain-conveyor face haulage is two to three times that for hand loading.

Principal causes of delays with chain conveyors face haulage are: Keeping the pans in alignment to prevent the flights from riding to the top of the coal in the pan line; unloading coal to get the flights back in position; and adding sections to or taking them from the pan line.

## CONCLUSIONS

Supervision and planning are important factors in the ability of face-haulage equipment to move mined coal from the face. Except where coal is loaded directly into mine-car face haulage and where chain-conveyor face haulage is loading directly by mobile loaders, the face haulage can handle more than results shown by this study.

The extensible belt is the latest type of face haulage adaptable for use behind continuous-mining machines in coal more than 50 inches thick. Peak loads are moved speedily and generally without surge storage facilities commonly used with shuttle-car haulage.

Shuttle-car face haulage is most widely used, can be adapted for use with present-day face equipment, and has flexibility.

Although the chain conveyor has many faults and has not been improved in years, it is the best face haulage for mining in thin coal.

Mine-car face haulage has been decreasing in use, but results at one mine show what can be done by supervision, planning, and large mine cars.

## APPENDIX I

### Classification of Mine Employees

### Mine 1 Employees

| | Shift | | | |
|---|---|---|---|---|
| Classification | 1st | 2d | 3d | Total |
| Shortwall auger continuous-mining units (a). | 10 | 10 | - | 20 |
| Shaking conveyor units (b)................. | 35 | 35 | - | 70 |
| Total men on units........................ | 45 | 45 | - | 90 |
| Other underground employees................ | 16 | 16 | 13 | 45 |
| Supervisory and inspection................. | 3 | 2 | - | 5 |
| Total underground employees............... | 64 | 63 | 13 | 140 |
| Total surface employees................... | 5 | 5 | - | 10 |
| Total surface and underground employees. | 69 | 68 | 13 | 150 |

### Mine 2 Employees

| | | | | |
|---|---|---|---|---|
| Shortwall auger continuous-mining units (a): | | | | |
| Section foremen............................ | 1 | 1 | - | 2 |
| Continuous-mining machine operators......... | 2 | 2 | - | 4 |
| Continuous-mining machine operators' helpers.................................. | 4 | 4 | - | 8 |
| Supply men................................. | 2 | 2 | - | 4 |
| Total underground employees............... | 9 | 9 | - | 18 |
| Total surface employees................... | 5 | 3 | - | 8 |
| Total surface and underground employees. | 14 | 12 | - | 26 |

### Mine 3 Employees

| | | | | |
|---|---|---|---|---|
| Mobile-loading units with bridge and chain conveyors developing main and panel entries (a)............................... | 17 | 17 | - | 34 |
| Mobile-loading units with chain conveyors mining rooms (b).......................... | 9 | 9 | 9 | 27 |
| Mobile-loading units with chain conveyors developing entries and mining rooms (c)... | 17 | 17 | - | 34 |
| Total men on units........................ | 43 | 43 | 9 | 95 |
| Other underground employees................ | 8 | 4 | 11 | 23 |
| Supervisory and inspection................. | 1 | 1 | - | 2 |
| Total underground employees............... | 52 | 48 | 20 | 120 |
| Total surface employees................... | 10 | 2 | - | 12 |
| Total surface and underground employees. | 62 | 50 | 20 | 132 |

Mine 4 Employees

| Classification | Shift | | | Total |
|---|---|---|---|---|
| | 1st | 2d | 3d | |
| Ripper-type continuous-mining units: | | | | |
| Extensible-belt units in rooms (a).......... | 12 | 12 | 12 | 36 |
| Shuttle-car unit in butt entries (b)........ | 7 | 7 | 7 | 21 |
| Shuttle-car unit in rooms (c)............... | 7 | 7 | 7 | 21 |
| Shuttle-car units in main entries (d)....... | 16 | 16 | 16 | 48 |
| Total men on units......................... | 42 | 42 | 42 | 126 |
| Other underground employees................ | 40 | 18 | 18 | 76 |
| Supervisory and inspection................. | 3 | 1 | 1 | 5 |
| Total underground employees............... | 85 | 61 | 61 | 207 |
| Total surface employees................... | 17 | 6 | 7 | 30 |
| Total surface and underground employees. | 102 | 67 | 68 | 237 |

Mine 5 Employees

| | | | | |
|---|---|---|---|---|
| Boring-type continuous-mining extensible belt type (a): | | | | |
| Section foremen............................ | 1 | 1 | - | 2 |
| Continuous-mining machine operators......... | 1 | 1 | - | 2 |
| Continuous-mining machine operators' helpers.................................. | 1 | 1 | - | 2 |
| Roof bolters............................... | 2 | 2 | - | 4 |
| Timbermen.................................. | 1 | 1 | - | 2 |
| Mechanics.................................. | 1 | 1 | - | 2 |
| Total men on units........................ | 7 | 7 | - | 14 |
| Total underground employees............... | 7 | 7 | - | 14 |
| Total surface employees................... | 3 | 3 | - | 6 |
| Total surface and underground employees. | 10 | 10 | - | 20 |

Mine 6 Employees

| | | | | |
|---|---|---|---|---|
| Ripper type continuous-mining units, shuttle cars to mine cars in entries (a)...... | 30 | 30 | 30 | 90 |
| Ripper type continuous-mining units, shuttle cars to belts (b).................... | 13-2/3 | 13-2/3 | 13-2/3 | 41 |
| Mobile-loading units, shuttle cars to mine cars (c).................................. | 16 | 16 | 16 | 48 |
| Track-mounted units to mine cars (d)........ | 25 | 25 | 25 | 75 |
| Total men on units........................ | 84-2/3 | 84-2/3 | 84-2/3 | 254 |
| Other underground employees................ | 65 | 43 | 40 | 148 |
| Supervisory and inspection................. | 7 | 2 | 2 | 11 |
| Total underground employees............... | 156-2/3 | 129-2/3 | 126-2/3 | 413 |
| Total surface employees................... | 48 | 11 | 9 | 68 |
| Total surface and underground employees. | 204-2/3 | 140-2/3 | 135-2/3 | 481 |

### Mine 7 Employees

| Classification | Shift |  |  | Total |
|---|---|---|---|---|
|  | 1st | 2d | 3d |  |
| Ripper-type continuous-mining extensible belt units (a) | 12 | 12 | 12 | 36 |
| Mobile-loading shuttle-car units (b) and (c) | 108 | 108 | 108 | 324 |
| Total men on units | 120 | 120 | 120 | 360 |
| Other underground employees | 40 | 40 | 40 | 120 |
| Supervisory and inspection | 12 | 12 | 11 | 35 |
| Total underground employees | 172 | 172 | 171 | 515 |
| Total surface employees | 29 | 28 | 13 | 70 |
| Total surface and underground employees | 201 | 200 | 184 | 585 |

### Mine 8 Employees

|  |  |  |  |  |
|---|---|---|---|---|
| Ripper-type continuous-mining shuttle car units (a) | 14 | 14 | - | 28 |
| Mobile-loading shuttle-car units (b) | 40 | 40 | - | 80 |
| Total men on units | 54 | 54 | - | 108 |
| Other underground employees | 21 | 12 | 8 | 41 |
| Supervisory and inspection | 5 | 1 | - | 6 |
| Total underground employees | 80 | 67 | 8 | 155 |
| Total surface employees | 21 | 12 | - | 33 |
| Total surface and underground employees | 101 | 79 | 8 | 188 |

### Mine 9 Employees

|  |  |  |  |  |
|---|---|---|---|---|
| Track-mounted units, main entries (a) | 20 | 20 | 10 | 50 |
| Track-mounted units, combination (b) | 44 | 44 | 22 | 110 |
| Track-mounted units, wide (c) | 36 | 36 | - | 72 |
| Track-mounted units, bull crew (d) | - | - | 12 | 12 |
| Total men on units | 100 | 100 | 44 | 244 |
| Other underground employees | 54 | 53 | 53 | 160 |
| Supervisory and inspection | 8 | 7 | 7 | 22 |
| Total underground employees | 162 | 160 | 104 | 426 |
| Total surface employees | 39 | 30 | 30 | 99 |
| Total surface and underground employees | 201 | 190 | 134 | 525 |

Mine 10 Employees

| | Shift | | | |
|---|---|---|---|---|
| Classification | 1st | 2d | 3d | Total |
| Mobile-loading shuttle-car units on development (a) | 54-2/3 | 54-2/3 | 54-2/3 | 164 |
| Track-mounted units with mine cars on development (b) | 27-1/3 | 27-1/3 | 27-1/3 | 82 |
| Mobile-loading shuttle-car units on retreat (c) | 95-2/3 | 95-2/3 | 95-2/3 | 287 |
| Track-mounted units with mine cars on retreat (d) | 27-1/3 | 27-1/3 | 27-1/3 | 82 |
| Total men on units | 205 | 205 | 205 | 615 |
| Other underground employees | 50 | 50 | 25 | 125 |
| Supervisory and inspection | 5 | 3 | 2 | 10 |
| Total underground employees | 260 | 258 | 232 | 750 |
| Total surface employees | 52 | 24 | 18 | 94 |
| Total surface and underground employees | 312 | 282 | 250 | 844 |

Mine 11 Employees

| | | | | |
|---|---|---|---|---|
| Continuous-mining extensible belt units (a) | 15-1/2 | 15-1/2 | - | 31 |
| Slabbing mobile loading shuttle-car units (b) | 16-1/2 | 16-1/2 | - | 33 |
| Mobile loading shuttle-car units: | | | | |
| Entry development units (c) | 40 | 40 | - | 80 |
| Panel development units (d) | 20 | 20 | 20 | 60 |
| Panel and room-mining units (e) | 20 | 20 | - | 40 |
| Total men on units | 112 | 112 | 20 | 244 |
| Other underground employees | 143 | 43 | 47 | 233 |
| Supervisory and inspection | 8 | 2 | 4 | 14 |
| Total underground employees | 263 | 157 | 71 | 491 |
| Total surface employees | 45 | 45 | 14 | 104 |
| Total surface and underground employees | 308 | 202 | 85 | 595 |

Mine 12 Employees

| | | | | |
|---|---|---|---|---|
| Ripper-type continuous-mining units: | | | | |
| Extensible belts unit in rooms (a) | 7 | 7 | - | 14 |
| Shuttle-car unit extracting pillars (b) | 8 | 8 | - | 16 |
| Mobile-loading units: | | | | |
| Shuttle-car units extracting pillars (c) | 24 | 24 | - | 48 |
| Shuttle-car units, entry development (d) | 36 | 36 | - | 72 |
| Total men on units | 75 | 75 | - | 150 |
| Other underground employees | 25 | 5 | 24 | 54 |
| Supervisory and inspection | 3 | 3 | 2 | 8 |
| Total underground employees | 103 | 83 | 26 | 212 |
| Total surface employees | 26 | 17 | 6 | 49 |
| Total surface and underground employees | 129 | 100 | 32 | 261 |

Mine 13 Employees

| Classification | Shift |  |  | Total |
|---|---|---|---|---|
|  | 1st | 2d | 3d |  |
| No. 4 drift, Lower 5 Block: Mobile-loading units with shuttle cars (a)............... | 11 | 11 | 11 | 33 |
| No. 2 drift, Lower 5 Block: Mobile-loading units with shuttle cars and 30-inch belt (b)................................ | 15 | 15 | 15 | 45 |
| No. 1 drift, Middle 5 Block: Mobile-loading units with shuttle cars (c)............... | 15 | 15 | 15 | 45 |
| Total men on units....................... | 41 | 41 | 41 | 123 |
| Other underground employees................. | 2 | 2 | 2 | 6 |
| Supervisory and inspection.................. | 1 | - | 1 | 2 |
| Total underground employees............... | 44 | 43 | 44 | 131 |
| Total surface employees.................. | 59 | 31 | 17 | 107 |
| Total surface and underground employees. | 103 | 74 | 61 | 238 |

## APPENDIX II

## Summary of Data for Mines Studied

### Mine 1

Coalbed: Lower Freeport (D) Thickness of bed: 36 inches

| | Continuous mining, bridge and chain conveyors rooms | Hand loading, shaking conveyors, rooms and entries |
|---|---|---|
| | (a) | (b) |
| Thickness mined................inches.. | 30 | 30 |
| Percent of mine production............. | 36.4 | 63.6 |
| Hours per shift........................ | 8 | 8 |
| Number of units........................ | 2 | 5 |
| Unit shifts per day.................... | 4 | 10 |
| Average yield of clean coal...percent.. | 100 | 100 |
| Average width of place...........feet.. | 40 | 40-30 |
| Number of places in set................ | 2 | 2 |
| Average advance of working place, including crosscuts, per shift ...............................feet.. | 30 | - |
| Average daily production, raw coal ...............................tons.. | 400 | 700 |
| Average production per unit per shift, raw coal..........................do.. | 100 | 70 |
| Average production per man shift in unit crew, raw coal..............do.. | 20 | 10 |
| Average production per underground man shift, raw coal[1]............do.. | 10.5 | 6.9 |
| Average production per payroll man shift, raw coal[1]................do.. | 9.5 | 6.5 |

[1] Number of men prorated to percent of mine production.

Mine 2

Coalbed: Peerless

Thickness of bed: 42 inches

| | Continuous mining, bridge and chain conveyors, rooms (a) |
|---|---|
| Thickness mined.....inches.. | 42 |
| Percent of mine production..... | 100 |
| Hours per shift..... | 8 |
| Number of units..... | 2 |
| Unit shifts per day..... | 4 |
| Average yield of clean coal.....percent.. | 100 |
| Average width of place.....feet.. | 50 |
| Number of places in set..... | 1 |
| Average advance of working place, including crosscuts, per shift.....feet.. | 38 |
| Average daily production, raw coal.....tons.. | 540 |
| Average production per unit per shift, raw coal......do... | 135 |
| Average production per man shift in unit crew, raw coal.....do... | 30 |
| Average production per underground man shift, raw coal.....do... | 30 |
| Average production per payroll man shift, raw coal...do... | 20.8 |

## Mine 3

Coalbed: Cedar Grove Thickness of bed: 36 to 56 inches

| | Mobile loading | | |
|---|---|---|---|
| | Bridge chain conveyors, main and panel entries | Chain conveyor | |
| | | Rooms | Entries and rooms |
| | (a) | (b) | (c) |
| Thickness mined...............inches.. | 36 | 56 | 52 |
| Percent of mine production........... | 39.0 | 36.7 | 24.3 |
| Hours per shift...................... | 8 | 8 | 8 |
| Number of units...................... | 2 | 1 | 2 |
| Unit shifts per day.................. | 4 | 3 | 2 |
| Average yield of clean coal..percent.. | 87.5 | 87.5 | 87.5 |
| Average width of place..........feet.. | 20 | 40 | 40 |
| Number of places in set.............. | 4 | 2 | 2 |
| Average advance of working place, including crosscuts, per shift.........................feet.. | 42 | 11.5 | 12.1 |
| Average daily production, raw coal..........................tons.. | 548 | 516 | 342 |
| Average production per unit per shift raw coal..................do... | 137 | 172 | 171 |
| Average production per man shift in unit crew, raw coal..........do... | 16.1 | 19.1 | 20.1 |
| Average production per underground man shift, raw coal[1]..........tons.. | 12.5 | 14.3 | 8.6 |
| Average production per payroll man shift, raw coal[1]...........do... | 11.2 | 12.9 | 7.9 |

[1] Number of men prorated to percent of mine production.

## Mine 4

Coalbed: Pittsburgh (No. 8) Thickness of bed: 55 inches

| | Continuous mining | | | |
|---|---|---|---|---|
| | Extensible belts, rooms | Shuttle cars | | |
| | | Butt entries | Rooms | Main entries |
| | (a) | (b) | (c) | (d) |
| Thickness mined.................inches.. | 52 | 52 | 52 | 52 |
| Percent of mine production.............. | 45.6 | 12.0 | 18.8 | 23.6 |
| Hours per shift......................... | 8 | 8 | 8 | 8 |
| Number of units......................... | 2 | 1 | 1 | 2 |
| Unit shifts per day..................... | 6 | 3 | 3 | 6 |
| Average yield of clean coal.....percent.. | 90 | 90 | 90 | 90 |
| Average width of place............feet.. | 16 | 12 | 16 | 12 |
| Number of places in set................. | 1 | 3 | 1 | 5 |
| Average advance of working place including crosscuts, per shift...feet.. | 109 | 29 | 94 | 29 |
| Average daily production, raw coal..do... | 1,946 | 510 | 802 | 1,009 |
| Average production per unit per shift, raw coal..........................do... | 324 | 170 | 267 | 168 |
| Average production per manshift in unit crew, raw coal...............do... | 54.0 | 24.3 | 38.1 | 21.0 |
| Average production per underground man shift, raw coal[1].............do... | 26.7 | 16.4 | 22.2 | 15.0 |
| Average production per payroll man shift, raw coal[1].................do... | 22.6 | 14.6 | 19.1 | 13.6 |

[1] Number of men prorated to percent of mine production.

## Mine 5

Coalbed: Pittsburgh (No. 8) Thickness of bed: 54 inches

| | Continuous mining, extensible belt, rooms (a) |
|---|---|
| Thickness mined....................inches.. | 52 |
| Percent of mine production.................... | 100 |
| Hours per shift.................... | 8 |
| Number of units.................... | 1 |
| Unit shifts per day.................... | 2 |
| Average yield of clean coal....................percent.. | 100 |
| Average width of place....................feet.. | 16-1/2 |
| Number of places in set.................... | 1 |
| Average advance of working place, including crosscuts, per shift: | |
| 16-1/2-foot room....................feet.. | 65 |
| 9-1/2-foot crosscuts....................do.. | 80 |
| Average daily production, raw coal....................tons.. | 600 |
| Average production per unit per shift, raw coal........do.. | 300 |
| Average production per man shift in unit crew, raw coal....................do.. | 42.9 |
| Average production per underground man shift, raw raw coal[1]....................do.. | 42.9 |
| Average production per payroll man shift, raw coal[1]...do.. | 30.0 |

[1] Number of men prorated to percent of mine production.

## Mine 6

Coalbeds: Thick and Upper Freeport — Average thickness of beds: 42 and 98 inches

| | Continuous mining | | Mobile loading | |
|---|---|---|---|---|
| | Shuttle cars to mine cars, entries | Shuttle cars to belts, rooms-entries | Shuttle cars to mine cars, entries | Track mounted, to mine cars, entries |
| | (a) | (b) | (c) | (d) |
| Average thickness mined......inches.. | 42 to 84 | 51 | 42 to 98 | 72 to 98 |
| Percent of mine production......... | 32.2 | 16.2 | 22.6 | 29.0 |
| Hours per shift..... | 8 | 8 | 8 | 8 |
| Number of units..... | 4 | 2 | 2 | 3 |
| Unit shifts per day day................ | 12 | 6 | 6 | 9 |
| Average yield of clean coal ..........percent.. | 99.25 | 99.25 | 99.25 | 99.25 |
| Average width of place........feet.. | 16 | 16 | 14 | 14 |
| Number of places set................ | 4 | 5 | 5 | 5 |
| Average advance of working place, including crosscuts per shift....feet.. | 30 | 82 | 45 | 35 |
| Average daily production, raw coal .............tons.. | 1,362 | 686 | 956 | 1,227 |
| Average production per unit per shift, raw coal.....tons.. | 114 | 114 | 159 | 136 |
| Average production per man shift in unit crew, raw coal .............tons.. | 15.2 | 16.7 | 19.9 | 16.4 |

Mine 6 (Con.)

Coalbeds: Thick and Upper Freeport

Average thickness of beds: 42 and 98 inches

|  | Continuous mining |  | Mobile loading |  |
|---|---|---|---|---|
|  | Shuttle cars to mine cars, entries | Shuttle cars to belts, rooms-entries | Shuttle cars to mine cars, entries | Track mounted, to mine cars, entries |
|  | (a) | (b) | (c) | (d) |
| Average production per underground man shift, raw coal[1/] ..............tons.. | 9.7 | 10.2 | 11.4 | 10.1 |
| Average production per payroll man shift, raw coal[1/] .............tons.. | 8.4 | 8.8 | 9.7 | 8.7 |

[1/] Number of men prorated to percent of mine production.

## Mine 7

Coalbed: Pittsburgh No. 8 Thickness of bed: 62 inches

| | Continuous mining, extensible belts, rooms | Mobile loading, shuttle cars | |
|---|---|---|---|
| | | Rooms | Entries |
| | (a) | (b) | (c) |
| Thickness mined...............inches.. | 57 | 74 | 74 |
| Percent of mine production............ | 14.3 | 42.9 | 42.8 |
| Hours per shift....................... | 8 | 8 | 8 |
| Number of units....................... | 2 | 6 | 6 |
| Unit shifts per day................... | 6 | 18 | 18 |
| Average yield of clean coal..percent.. | 100 | 82 | 82 |
| Average width of place..........feet.. | 16 | 15 | 12 |
| Number of places in set............... | 1 | 7 | 5 |
| Average advance of working place, including crosscuts, per shift..........................feet.. | 55 | 7.9 | 13.6 |
| Average daily production, raw coal...........................tons.. | 1,201 | 3,604 | 3,595 |
| Average production per unit per shift, raw coal.................do... | 200 | 200 | 200 |
| Average production per man shift in unit crew, raw coal..........do... | 33.3 | 22.2 | 22.2 |
| Average production per underground man shift, raw coal[1]..........tons.. | 20.7 | 15.7 | 15.8 |
| Average production per payroll man shift, raw coal[1]...........do... | 17.7 | 13.9 | 13.9 |

[1] Number of men prorated to percent of mine production.

## Mine 8

Coalbed: Sewickley Thickness of bed: 65 inches

| | Continuous mining, shuttle cars, entries (a) | Mobile loading, shuttle cars, entries (b) |
|---|---|---|
| Thickness mined................inches.. | 65 | 65 |
| Percent of mine production............ | 33.3 | 66.7 |
| Hours per shift........................ | 8 | 8 |
| Number of units........................ | 2 | 4 |
| Unit shifts per day.................... | 4 | 8 |
| Average yield of clean coal...percent.. | 85 | 85 |
| Average width of place...........feet.. | 17 | 14 |
| Number of places in set................ | 5 | 5 |
| Average advance of working place, including crosscuts, per shift..feet.. | 13.6 | 15.6 |
| Average daily production, raw coal..............................tons.. | 1,020 | 2,040 |
| Average production per unit per shift, raw coal........................tons.. | 255 | 255 |
| Average production per man shift in unit crew, raw coal.............tons.. | 36.4 | 25.5 |
| Average production per underground man shift, raw coal[1]...........tons.. | 23.2 | 18.4 |
| Average production per payroll man shift, raw coal[1]...............tons.. | 18.5 | 15.3 |

[1] Number of men prorated to percent of mine production.

## Mine 9

Coalbed: Pittsburgh No. 8 Thickness of bed: 62 inches

| | Track-mounted | | | |
|---|---|---|---|---|
| | Main entries | Butt entries and rooms | Rooms | Room necks |
| | (a) | (b) | (c) | (d) |
| Thickness mined.............inches.. | 74 | 74 | 74 | 74 |
| Percent of mine production.......... | 15.9 | 43.6 | 35.9 | 4.6 |
| Hours per shift..................... | 8 | 8 | 8 | 8 |
| Number of units..................... | 2 | 4 | 3 | 2 |
| Unit shifts per day................. | 5 | 10 | 6 | 2 |
| Average yield of clean coal.....................percent.. | 65 | 65 | 65 | 65 |
| Average width of place........feet.. | 12 | 12 to 22 | 22 | 12 to 22 |
| Number of places in set............. | 6 | 8 to 10 | 12 | 12 |
| Average advance of working place, including crosscuts, per shift......................feet.. | 15 | 10 | 9 | - |
| Average daily production, raw coal........................tons.. | 1,615 | 4,430 | 3,648 | 462 |
| Average production per unit per shift, raw coal.............tons.. | 323 | 443 | 608 | 231 |
| Average production per man shift in unit crew, raw coal......tons.. | 32.3 | 40.3 | 50.7 | 38.5 |
| Average production per underground man shift, raw coal[1].......tons.. | 20.4 | 23.4 | 26.6 | 22.0 |
| Average production per payroll man shift, raw coal[1]...........tons.. | 17.0 | 19.0 | 21.1 | 18.5 |

---

[1] Number of men prorated to percent of mine production.

## Mine 10

Coalbed: Pittsburgh No. 8 Thickness of bed: 77-1/4 inches

| | Shuttle cars, entry development | Mine cars, entry development | Shuttle cars, on retreat | Mine cars, on retreat |
|---|---|---|---|---|
| | (a) | (b) | (c) | (d) |
| Thickness mined..............inches.. | 71-1/4 to 90-1/4 | 71-1/4 to 90-1/4 | 71-1/4 | 71-1/4 |
| Percent of mine production........... | 31.2 | 10.7 | 48.4 | 9.7 |
| Hours per shift...................... | 8 | 8 | 8 | 8 |
| Number of units...................... | 4 | 2 | 7 | 2 |
| Unit shifts per day.................. | 12 | 6 | 21 | 6 |
| Average yield of clean coal......................percent.. | 77 | 77 | 77 | 77 |
| Average width of place.........feet.. | 14 | 14 | 14 | 14 |
| Number of places in set.............. | 6 to 12 | 4 to 6 | 6 to 12 | 4 to 6 |
| Average advance of working place, including crosscuts, per shift........................feet.. | 12.2 | 9.0 | - | - |
| Average daily production, raw coal.........................tons.. | 2,901 | 999 | 4,500 | 900 |
| Average production per unit per shift, raw coal..............tons.. | 242 | 167 | 214 | 150 |
| Average production per man shift in unit crew, raw coal.......tons.. | 17.7 | 12.2 | 15.7 | 11.0 |
| Average production per underground man shift, raw coal[1]........tons.. | 14.1 | 10.3 | 12.8 | 9.5 |
| Average production per payroll man shift, raw coal[1]............tons.. | 12.3 | 9.3 | 11.3 | 8.7 |

[1] Number of men prorated to percent of mine production.

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Mine 11

Coalbed: Illinois No. 6 Thickness of bed: 84 inches

| | Continuous mining extensible belts, room mining | Mobile loading, shuttle cars | | | |
|---|---|---|---|---|---|
| | | Slab-bing unit | Entry devel-opment | Panel devel-opment | Panel and room mining |
| | (a) | (b) | (c) | (d) | (e) |
| Thickness mined..........inches.. | 78 | 78 | 78 | 78 | 78 to 84 |
| Percent of mine production....... | 19.0 | 18.9 | 27.6 | 20.7 | 13.8 |
| Hours per shift.................. | 8 | 8 | 8 | 8 | 8 |
| Number of units.................. | 2 | 1 | 2 | 1 | 1 |
| Unit shifts per day.............. | 4 | 2 | 4 | 3 | 2 |
| Average yield of clean coal ......................percent.. | 92 | 92 | 92 | 92 | 92 |
| Average width of place.....feet.. | 12-1/2 | (16-1/2 mined) | 16 | 14 | 24 to 28 |
| Number of places in set.......... | 2 | 1 | 5 | 3 | 6 |
| Average advance of working place, including crosscuts, per shift.................feet.. | 180 | 275 | 39 | 75 | 22.3 |
| Average daily production, raw coal..................tons.. | 2,200 | 2,200 | 3,200 | 2,400 | 1,600 |
| Average production per unit per shift, raw coal.......tons.. | 550 | 1,100 | 800 | 800 | 800 |
| Average production per man shift in unit crew, raw coal .........................tons.. | 71.0 | 66.7 | 40 | 40 | 40 |
| Average production per underground man shift, raw coal[1] .........................tons.. | 28.2 | 27.5 | 21.6 | 21.6 | 21.6 |
| Average production per payroll man shift, raw coal[1].....tons.. | 22.4 | 22.0 | 18.1 | 18.2 | 18.2 |

[1] Number of men prorated to percent of mine production.

## Mine 12

Coalbed: Pittsburgh No. 8 Thickness of bed: 96 inches

| | Continuous mining | | Mobile loading, shuttle cars | |
|---|---|---|---|---|
| | Extensible belts, rooms | Shuttle cars, pillar extraction | Pillar extraction | Entries |
| | (a) | (b) | (c) | (d) |
| Thickness mined.......inches.. | 84 | 72 to 84 | 84 | 84 |
| Percent of mine production.... | 16.7 | 10.1 | 29.3 | 43.9 |
| Hours per shift.............. | 8 | 8 | 8 | 8 |
| Number of units............... | 1 | 1 | 2 | 3 |
| Unit shifts per day........... | 2 | 2 | 4 | 6 |
| Average yield of clean coal...............percent.. | 93 | 93 | 93 | 93 |
| Average width of place..feet.. | 16 | 15 | 14 | 14 |
| Number of places in set....... | 2 | 10 | 10 | 7 to 14 |
| Average advance of working place, including crosscuts, per shift.............feet.. | 120 | 95 | 130 | 130 |
| Average daily production, raw coal..............tons.. | 1,080 | 650 | 1,888 | 2,832 |
| Average production per unit per shift, raw coal...tons.. | 540 | 325 | 472 | 472 |
| Average production per man shift in unit crew, raw coal..................tons.. | 77.1 | 40.6 | 39.3 | 39.3 |
| Average production per underground man shift, raw coal[1]............tons.. | 45.0 | 29.5 | 30.4 | 27.2 |
| Average production per payroll man shift, raw coal[1]................tons.. | 33.8 | 24.1 | 24.8 | 22.5 |

[1] Number of men prorated to percent of mine production.

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## Mine 13

Coalbeds: Lower and Middle 5 Block    Thickness of beds: 84 and 96 inches

| | Mobile loading | | |
|---|---|---|---|
| | Shuttle cars to dumps, entries | Shuttle cars to belt, entries and rooms on retreat | Shuttle cars to dumps, entries and rooms on retreat |
| | (a) | (b) | (c) |
| Thickness mined................inches.. | 50 | 50 to 84 | 96 |
| Percent of mine production............ | 24.5 | 30.0 | 45.5 |
| Hours per shift........................ | 8 | 8 | 8 |
| Number of units........................ | 1 | 1 | 1 |
| Unit shifts per day.................... | 3 | 3 | 3 |
| Average yield of clean coal...percent.. | 77 | 77 | 77 |
| Average width of place...........feet.. | 22 | 22 to 24 | 22 to 24 |
| Number of places is set................ | 4 | 4 | 4 |
| Average advance of working place, including crosscuts, per shift..feet.. | 21.3 | - | - |
| Average daily production, raw coal............................tons.. | 1,052 | 1,286 | 1,948 |
| Average production per unit per shift, raw coal........................tons.. | 351 | 429 | 649 |
| Average production per man shift in unit crew, raw coal..............tons.. | 31.9 | 28.6 | 43.3 |
| Average production per underground man shift, raw coal[1]...........tons.. | 29.6 | 27.0 | 40.6 |
| Average production per payroll man shift, raw coal[1]................tons.. | 17.1 | 16.2 | 20.0 |

1/ Number of men prorated to percent of mine production.

# APPENDIX III

## Previous Publications in the Series

TOENGES, A. L. and ANDERSON, R. L., Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines. Progress Report 1: Bureau of Mines Inf. Circ. 7014, 1938, 56 pp.

TOENGES, A. L., and JONES, F. A., Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines. Progress Report 2: Bureau of Mines Inf. Circ. 7067, 1939, 58 pp.

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TOENGES, A. L., MAIZE, E. R., and JONES, F. A., Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines. Progress Report 4. Extraction of Pillars With Mechanized Equipment: Bureau of Mines Inf. Circ. 7223, 1942, 59 pp.

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SHIELDS, J. J., DOWD, J. J., and HALEY, W. A., Mechanical Mining in Some Bituminous Coal Mines. Progress Report 8: Methods and Equipment Used in Underground Development: Bureau of Mines Inf. Circ. 7813, 1957, 67 pp.

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